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The Great Barrier Reef of Australia: Its Products and Potentialities. By W. Saville Kent. With a chart, 48 mezzotype plates, 16 chromo plates, and figures in the text. London: W. H. Allen & Co. 1893. 4to, pp. xii, 387.

SINCE the appearance of Dana's magnificent 'Report on the Zoophytes of Wilkes's Exploring Expedition' nothing has been published containing so much new information regarding polyps as the superb volume before us. It contains a popular account of the fauna of the Great Barrier Reef by W. Saville Kent, Commissioner of Fisheries to the Government of West Australia. The report is also interesting to the naturalist from the detailed account, accompanied by colored figures and photographs, of numerous species of corals taken from life. Unfortunately, the colored sketches are not as successful as the photographs. The chromolithographic plates of the fishes, the sea-anemones, the holothurians, the alcyonarians, and echinoderms, as well as of other animals living upon the reef, can hardly be compared for accuracy or for beauty to such illustrations as accompany Dana's 'Zoophytes,' Semper's 'Holothurians of the Philippine Islands,' or some of the colored sketches of tro-

pical fishes published by the Godeffroy Museum.

Mr. Kent has, nevertheless, done more for those who have never had the good fortune to visit a reef than all the descriptions of former writers. He is not only an excellent naturalist, but also a most skilful photographer. The forty-eight photo-mezzotype plates give us pictures of the Great Barrier Reef of Australia of the greatest beauty. It is difficult to imagine that any illustrations could convey to one who has not seen a coral reef so admirable an idea of its structure and appearance. The greater number of the reefs which have been described are found in districts where the tide has but little rise and fall, so that naturalists have usually limited their accounts of a growing reef to what could be seen through a water-glass, and from a boat floating over the submerged reef. Mr. Kent worked in a region where the tide has, in some cases, a range of eighteen feet, and was thus able to photograph extensive tracts or detailed portions left bare at very low tides. In some cases his camera has even reproduced patches of corals below the surface, so that it becomes an easy matter to imagine these vast fields of corals as they would appear when covered by the rising tide. The great rise and fall of the tides, subjecting parts of the reef to extreme atmospheric influences, naturally explains the existence of extensive tracts of dead corals between the living banks and high-water mark.

As Fish Commissioner, our author naturally devotes a good part of his volume to the practical side of his subject. He has interesting chapters on the pearl and the oyster-fisheries, and deals also in a very interesting manner with the holothurian fishery, which is the most important of the Queensland marine industries, yielding about £23,000 a year. The bêche-de-mer are collected by hand at low water and are prepared entirely for the Chinese market. As their food consists mainly of foraminiferal sand, they can hardly be called succulent. As soon as collected the holothurians are boiled for a short time, split open, gutted and smoked, and are shipped when dry and crisp. To a European they are not attractive, looking like so many charred sausages; as eaten in Japan, cut up in small slices and thoroughly disguised by the sauce in which they are served, they become nearly as palatable as a piece of cartilage properly seasoned.

While we owe to Mr. Kent so valuable an account of the appearance of the Great Bar rier Reef, he has added comparatively little t the description given by Jukes, between 184 and 1846, so far as it relates to the genera theory of the formation of coral reefs. Th discussion by Mr. Kent of the coral-reef theor is limited to a reproduction of its essenti points as given by Darwin, to a short stat ment of its acceptance by Dana, and furthe to the practical adoption of Bonney's objec tions to the attacks on the Darwinian ree theory by Murray and others. Even grantin that subsidence has been in many districts th principal factor in the formation of coral reef it by no means follows that subsidence is th only explanation for the formation of cor reefs in an equal number of other district Many of those who oppose the Darwinia theory merely state that it is not sufficient explain the simultaneous existence of fringing reefs, of barrier reefs, and of atolls in certain areas, and they look for simpler natural causes to explain their growth. It is no answer to their arguments to call the atolls of those regions pseudo-atolls, or to exclude them altogether, as is frequently done, from the discussion.

The bases for the growth of corals may as well have been formed by elevation as by subsidence; there is no greater improbability in the one than in the other theory. In fact, many of the observations made by Mr. Kent fully support the objections to the theory of subsidence as explaining the formation of all coral reefs; and were he more familiar with the recent literature on the subject, he would have learned that the coral-reef theory is not quite as simple as he gives his readers to understand. It is becoming more and more apparent that nothing short of a renewed study of the elevated reefs of some favorable locality, coupled with borings carried to great depths through an atoll in a region of subsidence as well as through the outer edge of a barrier reef, will once for all settle questions which are now answered by more or less lucky guesses.

Mr. Kent looks for the conditions of subsidence which have made the formation of the Great Barrier Reef possible in the former undoubted connection of Australia with Tasmania and New Guinea; and if that is not satisfactory, he is quite ready to call upon a still greater subsidence of the Australian Continent as shown by its presumed connection with New Zealand. If, as is probable, and as Mr. Kent suggests, the Great Barrier Reef existed as a narrow fringing reef in the late Tertiary, there has elapsed more than ample time also for its transformation into the Great Barrier Reef of to-day from other causes than those called upon by him. The Great Barrier Reef has entirely obliterated the Australian coast-shelf itself, and it may have found upon that all the conditions of depth necessary for the vigorous growth, both vertically and laterally, of the original insignificant fringing reef of the northeastern coast of Australia.

The Government of Queensland is to be congratulated upon having placed so competent a naturalist as Mr. Kent in charge of the exploration of the Great Barrier Reef, and also upon having published so valuable a contribution to marine zoölogy. Nothing would do more for the practical objects which the Government has in view than the establishment in Torres Strait of the Biological Station suggested by Mr. Kent. The problems which the fisherman wishes to have solved can be attacked by naturalists only when working continuously at a spot so admirably located for all marine investigations as Thursday Island, and within easy reach of the rich fauna of the Great Barrier Reef.

We may state for the benefit of instructors and others that twelve of the characteristic reef views have been enlarged for use as illustrations, and are to be obtained separately from the publishers. Lantern slides of any of the photographs can also be purchased.

Alexander Pallick.

January 1894.

THE GREAT BARRIER REEF

OF AUSTRALIA;

ITS PRODUCTS AND POTENTIALITIES.

By the same Author

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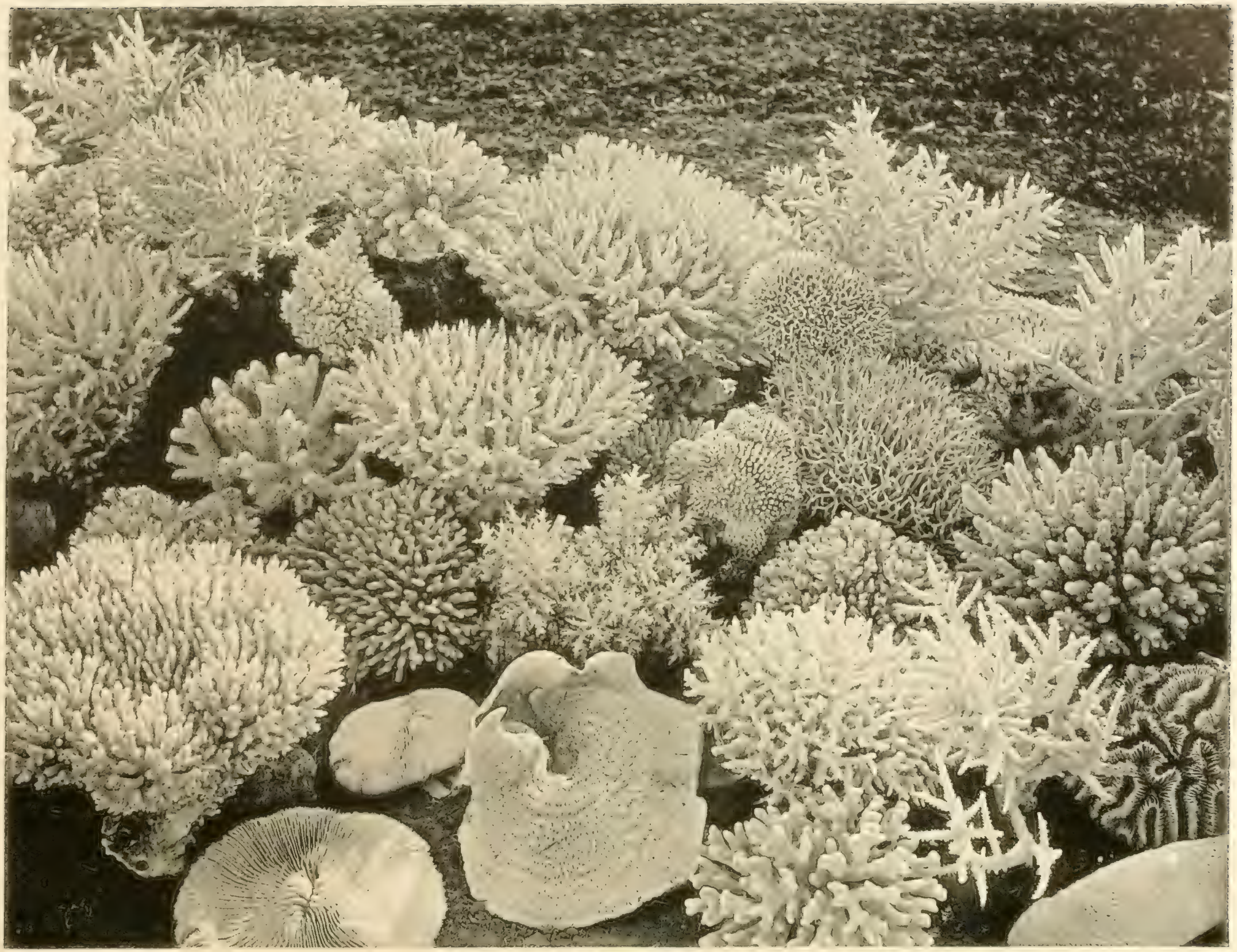

W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

BLEACHED CORAL SPECIMENS FROM THE GREAT BARRIER REEF.

THE GREAT BARRIER REEF
OF AUSTRALIA;

ITS PRODUCTS AND POTENTIALITIES.

BY

W. SAVILLE-KENT, F.L.S., F.Z.S., F.I.Inst.,

Past President Royal Society of Queensland; Formerly Assistant in the Natural History Departments of the British Museum; Commissioner of Fisheries to the Government of West Australia and late of Tasmania and Queensland.

Author of "A Manual of the Infusoria," &c., &c.

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OF THE

AUSTRALIAN GREAT BARRIER REGION.

London:

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TO THE

HON. SIR SAMUEL WALKER GRIFFITH,

K.C.M.G., Q.C., &c.,

CHIEF JUSTICE OF QUEENSLAND

AND

LATE PREMIER OF THE MINISTRY,

UNDER WHOSE AUSPICES, AND WITH WHOSE ENCOURAGING SUPPORT,
THE FACTS AND MATERIALS HEREIN SET FORTH
WERE RENDERED ACCESSIBLE,

This Volume

ON THE

GREAT BARRIER REEF OF AUSTRALIA

IS DEDICATED, AS A MARK OF ESTEEM,

BY THE AUTHOR.

"*Thy way is in the sea, and Thy paths in the great waters.*"

PSALM lxxvii. *v.* 19.

PREFACE.

A DAY-DREAM of the author, when attached, in years gone by, to the Natural History Department of the British Museum, and for the nonce engaged in the arrangement and nomenclature of the magnificent collection of Madrepores or Stony-corals in that Institution, was to be afforded an opportunity of seeing those organisms growing in their native seas and in their wonderful living tints. That this day-dream, contrary to many of its order, has been substantially realised, this volume, to a large extent, bears witness. The impressions which the actual sight of growing coral-reefs yielded the author are here reproduced, with the fidelity that photography alone can compass, for the benefit of those who, possessing the desire, lack opportunity of making a personal acquaintance with this fairy-land of fact.

The motives of this volume are, at the same time, manifold. A primary object is to place the reading public generally, and the scientific world in particular, in possession of more extensive and accurate information than has hitherto been at their disposal, concerning the external features and the detailed composition of coral-reefs, as represented by that largest existing coral structure, the Great Barrier Reef of Australia; also to bring forward evidence bearing upon the opposing theories concerning the telluric conditions under which that vast reef originated.

Another prominent purpose of the work is to direct attention to the harvest-field, rich from both a commercial and a scientific standpoint, that this Queensland possession constitutes, with the hope that it may lead, on both sides, to a more thorough exploration and development of its marvellous resources.

A leading feature in this volume is the series of monochrome illustrations. It is anticipated that they will assist materially towards demonstrating the capabilities of photo-

graphy for the delineation of coral-reef structures in the concrete, and of the living organisms associated with them. A few of these photographic illustrations, it may be mentioned, were sent to England and exhibited, in the author's name, by Sir William Flower, F.R.S., at the conversaziones of the Royal Society at Burlington House in 1891, while a more complete series of them was displayed at the gatherings of the Royal Society held last year. It may be said that by no process other than that of photography is it possible to represent areas of coral-growths that are uncovered by the sea for such short and uncertain intervals, accurately. Considerable originality may be claimed for these pictures. With one or two exceptions, the most notable of which is an enlarged copy of a photograph of a small foreground area of a Fiji reef, taken by the Hon. R. Abercromby, on view in the coral gallery of the British (Nat. Hist.) Museum, the subject has not previously been dealt with under the camera. In no instance has it, as in this volume, been extensively or systematically treated ; and it is hoped that the results herein attained may lead to a much more extensive adoption, by biologists, of photographic processes, for the illustration of living corals and other aquatic organisms. In the matter of the life-coloured figures included in the chromo-lithographic plate series, it appears possible, as suggested in the concluding chapter, that the new source of artistic design exemplified by these delineations may sooner or later be turned to practical account. To those specially interested in the subject of reef-formation, the series of enlargements of a selected number of the more characteristic reef-views contained in this volume, which are issued by the same Publishers, will probably prove acceptable. In many instances, these enlargements serve to bring into prominent notice structural details and component organisms that are liable to escape attention in the smaller pictures.

The extraordinary wealth of coral and other organic life prevalent throughout the Barrier district, whilst necessarily dealt with in this volume superficially, is perhaps sufficiently manifested to convey to biologists some idea of the rich field that it offers for original investigation. Sufficient also is probably submitted to win from them a unanimous endorsement of the author's views, expressed in the concluding chapter, respecting the unparalleled suitability of the Great Barrier district in general, and of Thursday Island in particular, for the establishment of an efficiently-equipped zoological station.

The acknowledgments that have to be chronicled in this prefatory notice are numerous. The first and most substantial one is due to the Queensland Government, for the facilities and material assistance liberally accorded, which have enabled the author to place on record so

considerable an exposition of coral-reef organisation. In the same matter, and also for much personal hospitality during the investigation of the Torres Strait district, the Honourable John Douglas, Government resident at Thursday Island, and Mr. Frank Jardine, of Somerset and the Albany Pass, must have special mention. Valuable and willing assistance was rendered by the Harbourmasters and Customs officials of Cooktown, Cairns, Townsville, Mackay, Bowen, and other ports, which were made the bases of excursions to various districts of the Barrier.

A few months' residence in England, before taking up an official engagement with the Western Australian Government, has proved all too short for the working out of fully-detailed catalogues of the very extensive coral collections made throughout the Barrier district. The collection has been presented to the British (Natural History) Museum ; and a detailed list of the species of the single genus Madrepora, numbering no fewer than seventy species identified, many of which are described as new, by Mr. George Brook, F.L.S., at present engaged on the compilation of a systematic catalogue of the British Museum collections, is added to this volume, in the form of an appendix, together with a rougher list, complete as to the generic identifications only, of the representatives of the residual mass, for which the author is responsible.

Whenever the investigations now in progress are more advanced, and the necessary leisure is afforded him, the author hopes to complete, for contribution to one or more of the scientific societies, fully detailed reports upon the coral fauna of the Australian seas, including that of the Great Barrier and of the Northern and Western Australian districts. For assistance towards the accomplishment of this more comprehensive, and at the same time more purely technical, task, the author is indebted—as in the case of his earlier monograph on the Infusoria—for substantial assistance from the Government Scientific Research Fund, disbursed by the Council of the Royal Society.

Acknowledgments are due to Professor F. J. Bell, M.A., of the Zoological Department of the Natural History Museum, for the specific identification of the greater number of the Holothuridæ or Bêche-de-mer figured and described in this volume, and for his indication to the author of such types among them as are new to science ; and a like indebtedness must be owned to Professor A. C. Haddon, M.A., of the Royal College of Science, Dublin, for services associated with the identification of the Torres Strait and Barrier Reef anemones.

The warmest thanks are accorded Professor G. B. Howes, F.L.S., of the Royal College of

Science, South Kensington, for invaluable services rendered, in posting the author in the latest literature bearing upon many subjects dealt with in this volume, for placing him in communication with specialists working at certain of the more obscure groups, and for substantial assistance in the revision of the proof-sheets.

The manner in which the author's photographs have been reproduced by the London Stereoscopic Company and Messrs. Waterlow & Sons, is excellent beyond comment, and Messrs. Riddle & Couchman have produced painstaking and faithful representations of the author's original water-colour sketches.

The thanks of the author are also due to the publishers, Messrs. W. H. Allen & Co., Limited, who have throughout seconded his efforts to place the illustrations before the reader in the most perfect manner possible, and who have spared neither trouble nor expense in every detail of the production.

London, February 24, 1893.

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LIST OF PHOTO-MEZZOTYPE PLATES.

FOR THE USE OF MUSEUMS, SCIENTIFIC SOCIETIES, COLLEGES, SCHOOLS, ETC.

The following twelve of the illustrations have been enlarged by photo-mezzotype process, and can be had from the Publishers, Messrs. W. H. ALLEN & CO., Limited, 13, Waterloo Place, London, S.W. :—

	PLATE		PLATE
Crescent Reef, Outer Barrier Series, No. 6	XVI.	Bleached Coral Specimens from Great Barrier Reef	I.
Porites Islet, Fringing Reef, Port Denison	V.	Madrepore Islet, Fringing Reef, Port Denison ...	V.
Madrepore Lagoon, Fringing Reef, Port Denison ...	IX.	Low Woody Reef, Outer Barrier Series, No. 5 ...	XV.
Charted Reef, Thursday Island, Torres Strait ...	II.	"Dog" Reef, Saddle-Back Island, Port Denison ...	VIII.
Crescent Reef, Outer Barrier Series, No. 7	XVII.	Skull Reef, Outer Barrier Series, No. 4	XIV.
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LIST OF PHOTO-MEZZOTYPE PLATES.

LIST OF CHROMO PLATES.

INTRODUCTORY.

THE Great Barrier Coral Reef of Australia, the marvellous structure and extent of which were first made known to the world through the explorations of Captain Cook, is one of the wonders of the universe. Its linear measurement is no less than 1,250 miles, beginning with its northern origin in Torres Strait, about $9\frac{1}{2}^\circ$ south latitude, in close proximity to New Guinea, and thence stretching away as far as Lady Elliot Island, the southernmost true coral islet in the system, situated in the parallel of 24°, somewhat south of the bold mainland promontory known as Bustard Head. Its whole area, as shown by the foregoing data, lies entirely within the territorial jurisdiction of Queensland, of which colony it constitutes, *in esse* and *in posse*, one of the most valuable possessions. Some idea of the monetary importance to Queensland of the Great Barrier Coral Reef area may be gained from the fact that raw material to the value of over £100,000 is obtained annually from the reefs and the intervening waters, and exported from the colony. This sum, moreover, probably represents but a fractional portion of what it will be worth when the prolific resources of the region have been fully developed. The items which have contributed in the past, and are likely to contribute in the future, most extensively towards the production of the substantial figures quoted are the pearl and pearl-shell and the Trepang (or Bêche-de-mer) fisheries. These are capable of development to an almost unlimited extent, and in addition to them there are other fishing and allied industries which await but the advent of scientifically applied labour, and the necessary capital, to yield a rich increase to the Colony's wealth.

The extreme linear measurement of the Great Barrier Reef along the Queensland coast-line approximates, as above recorded, to no less than 1,250 English miles. The distance from the mainland to the outer edge or boundary of this gigantic reef, or (more correctly) series of reefs varies somewhat in different districts. From Cape Weymouth, in the latitude of $12\frac{1}{2}^\circ$, to the Trinity Opening, $16\frac{1}{2}^\circ$ south, or an extent of 240 geographical miles, the average distance of the Barrier's outer edge from the mainland does not exceed

thirty miles. At one or two isolated points, such as the promontories of Cape Melville and of Cape Direction, the distance is as little as ten or twelve miles. At the northern and the southern extremities of this relatively uniform reef-enclosed channel, the proximity of the outer wall or boundary of the Barrier from the mainland increases considerably. At its northern end it follows a course due north, the trend of the mainland being north-west by north, until, opposite Cape York, Queensland's extreme northern point, there is an intervening distance of over ninety miles. Eastward of Torres Strait the outer wall of the Barrier describes a north and slightly north-easterly course, embracing what is known as the Warrior Reef, Murray and Darnley Islands, and ending in close proximity to the New Guinea coast. Southward from Cairns and the Trinity Opening, the outer edge of the Barrier for a stretch of nearly 180 miles lies off the mainland at a distance varying from forty to sixty miles. From this point it rapidly extends further seawards, its more northerly clearly-defined continuity disappears, and it becomes broken up into detached reefs and islets that are ultimately as remote as 150 miles from the Queensland coast-line.

The area enclosed between the outer edge of the Great Barrier Coral Reef and the Queensland mainland is necessarily of very considerable dimensions, and may be set down, at the lowest approximate estimate, at some 80,000 square geographical miles. This extensive area, throughout the greater part of its length, may be said to consist of a perfect archipelago of detached reefs and coral islets, the majority of the former of which are completely submerged, or only partially exposed to view at ordinary low water. Although usually represented as forming, with the exception of certain well-defined passages, a continuous wall throughout its length, the outer edge of the Great Barrier Reef must be more correctly described as consisting of a chain of detached reefs of variable lengths, with innumerable openings, only a few of which offer a secure passage for large-sized vessels. The list of these openings, enumerated and named on the Admiralty charts for the navigation of these waters, beginning with the Great North-East (or Bligh) Entrance in the extreme north, and ending with the wide and most southerly entrance of Curtis Channel, is as follows :—

LIST OF NAVIGABLE PASSAGES THROUGH THE GREAT BARRIER REEF.

*1. Bligh, or Great North-East Entrance.
2. Flinder's Entrance.
3. Yule Entrance.
4. Olinda Entrance.
5. Pandora Entrance.
6. Raine Island Entrance.
7. Black Rock Entrance.
8. Quoin Island Entrance.
9. Providential Channel (Cook, 1770).
10. Second Three Mile Opening.
11 First Three Mile Opening.
*12. One-and-a-Half Mile Opening.
13. Cook's Passage (1770).
*14. Lark Passage.
*15. Trinity Opening.
*16. Grafton Passage.
*17. Flora Pass.
18. Palm Passage.
19. Magnetic Passage.
*20. Flinder's Pass.
*21. Capricorn Channel.
*22. Curtis Channel.

The numbers in the above list associated with an asterisk indicate the only passages which are regularly used for navigation. Out of these, No. 1 represents the ordinary entrance through the Barrier of vessels of heavy draught proceeding from the east by what is known as the Outer Route, *viâ* Torres Strait, to India and China. The Raine Island Passage, No. 6, prior to the survey of the Great North-East Entrance, represented the main route from the east and south to Torres Strait; in consequence of the intricate and dangerous nature of its reefs and channels it is now, excepting for its occasional use by small craft, practically abandoned. Nos. 12 and 14 are commonly utilised by vessels sailing between Cooktown and New Guinea. Nos. 16 and 17 afford convenient entrances to the ports of Cairns and of Geraldton, while Capricorn and Curtis Channels represent the wide navigable openings through which all vessels from the south gain entry, proceeding by what is known as the Inner Route to Torres Strait, the Indian Ocean, and China Seas.

The linear chain of reefs that form the outer edge of the Barrier, together with the innumerable secondary reefs that are congregated closely within its boundaries, constitute a natural breakwater against the ever-reverberating surges of the Pacific Ocean, and thus convert the "Inner Route" into a relatively shallow and tranquil inland sea, which the largest ocean steamers traverse, for the greater part of the year, with open ports and on an even keel. This inner passage being thickly studded with islets, reefs, and shoals, its navigation is necessarily intricate, and gives employment, where vessels of heavy tonnage are concerned, to a large staff of experienced and highly efficient pilots. All danger in this inner passage, it is scarcely necessary to remark, is further reduced to a minimum by the very excellent system of lighting and beaconing that has been established by the Queensland Government. For the introduction and organisation of the system, special credit is due to Captain G. P. Heath, R.N., who recently retired, after having been Port Master to the colony for a period of thirty years. The lighting and beaconing of the Queensland coast-line is, as a matter of fact, frequently cited by navigators, the world over, as among the most efficient of its kind.

Further data concerning the structural features of the Great Barrier Reef, together with a summary and a discussion of the theories that have been most recently advanced with relation to the origin of coral formations, furnish the material for a separate chapter.

CHAPTER I.

DESCRIPTIVE DETAILS OF PHOTOTYPE PLATES.

IT has been thought desirable to devote this chapter to a detailed description of the forty-eight plates, comprising some sixty subjects, reproduced by photo-mechanical processes from the author's original negatives. These photographic subjects, including more particularly the reef-views, are referred to individually, or as a whole, or with reference to some specific detail, in various disconnected sections of the succeeding text. To many subscribers to this work the illustrations will, probably, prove the most prominent, if not the sole, attraction; in their interests, a condensed description of the most noteworthy illustrative features is obviously demanded.

PLATE I.

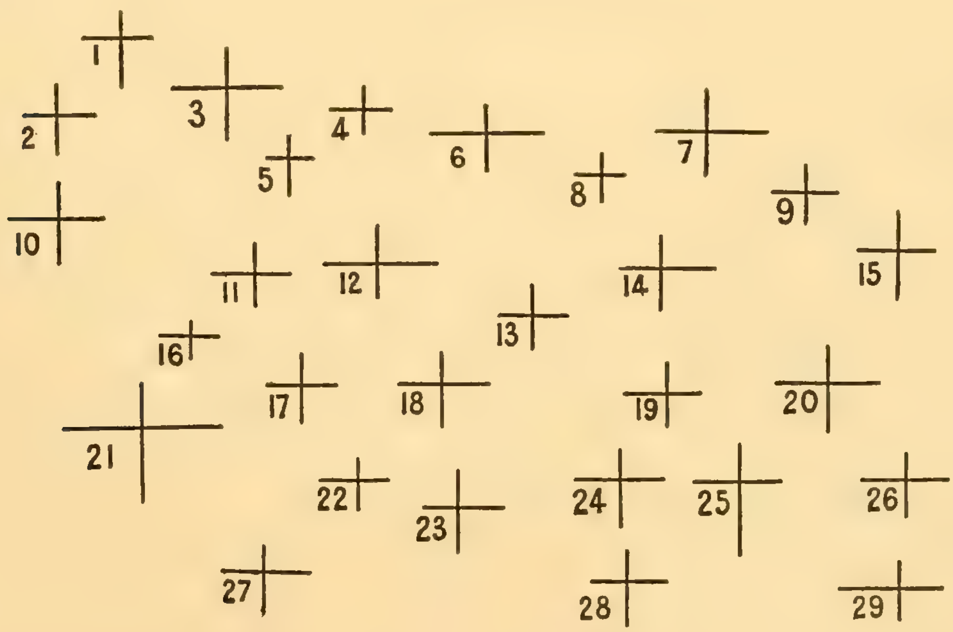
BLEACHED CORAL SPECIMENS FROM THE GREAT BARRIER REEF.

The initial plate in the series forms a fitting introduction to the main subject of this volume. It represents a typical collection of specimens obtained from the Great Barrier Reef in the neighbourhood of Port Denison, specially prepared by bleaching, for the export trade. Large quantities of this bleached coral are utilised, in conjunction with Barrier Reef shells, as the orthodox adornment of the innumerable oyster saloons throughout the Australian colonies, while many of the more ornamental varieties find a ready sale among retail purchasers for household decoration.

The identification of the specific varieties included in this introductory plate will be facilitated by a reference to the accompanying diagrammatic plan, in which a cross with an associated figure occupies the approximate position of each individual coral. The majority of the specimens included in this group are referable to the extensive genus Madrepora, and are for the most part remarkable in life for their brilliant coloration. The large bouquet-shaped mass, No. 21, towards the left-hand corner of the foreground, is, in its living condition, intense violet and identical with

the variety of which a small fragment is represented by Fig. 3 in Plate IX. in the coloured lithographs. It having proved on examination to be a hitherto undescribed species, Mr. George Brook, F.L.S.,—who is at present occupied in compiling a catalogue of all the Madreporaria in the National Collection,—has associated it in a recently published list, by way of compliment, with the author's name. In Nos. 12 and 24, occupying more central positions, are depicted a species closely allied to the form Fig. 17 of the same coloured plate. Like it, in life, they have the bases and main shafts of the branches buff colour, and all the terminations brilliant magenta. The more typical Stags'-horn corals, represented by Nos. 1, 3, 7, and 25 of the diagrammatic plan, vary, through innumerable shades of green, yellow, lilac, and brown. Occasionally, as in No. 15, *Madrepora laxa*, occupying the uppermost position on the right-hand side, the entire living corallum is, as depicted in Fig. 6 of the coloured plate previously quoted, a brilliant electric-blue.

DIAGRAMMATIC KEY TO PLATE I.



EXPLANATION.

1, 7, 25.	*Madrepora muricata* var.	13.	*Galaxea Esperi.*	20	*Madrepora Hemprichi* var.
2, 5.	*Madrepora rosaria.*	14.	*Seriatopora hystrix.*	21.	*Madrepora Kenti.*
3, 6, 10, 12, 24.	*Madrepora formosa.*	15.	*Madrepora laxa.*	22, 27.	*Fungia lacera.*
4, 11.	*Madrepora Bruggemanni.*	16, 19.	*Pocillopora damicornis.*	23.	*Podobacia crustacea.*
8.	*Seriatopora octoptera.*	17, 28.	*Stylopora palmata.*	26.	*Mussa multilobata.*
9.	*Madrepora conferta.*	18.	*Madrepora rosaria* var. *dumosa.*	29.	*Herpetolitha talpina.*

The very delicate and profusely branched species, *Madrepora rosaria* var., No. 18, located in an almost central position in the group, is most usually of a pale lemon-yellow hue throughout, with the exception of the extreme tips or distal terminations, which vary from white to the palest mauve

or flesh-pink. No. 26, towards the right-hand base, depicts one of the labyrinthine, coarsely-toothed Mussæ, the deep sunk valleys of which, in life, are usually bright myrtle-green ; the intervening spinous ridges are a rich golden-brown. Typical illustrations of the life-colours of this genus are included in Plate V. of the chromo-lithographic series. Mushroom-corals, genus Fungia, with its elongated affinity Herpetolitha, are represented by Nos. 22, 27, and 29. None of these bleached specimens are characterised, in life, by brilliant coloration : in most instances they are of a light brownish hue. An allied form, however, *Fungia crassitentaculata*, illustrated in the Phototype plates XXIII. and XXIV., and also in Plate VI. of the chromographic series, is conspicuous for the brilliant hues of its living tissues. *Galaxea Esperi*, No. 13, occupying a sub-central position, is characterised by a corallum which, in its dried condition, may be aptly compared with one of those wonder-raising products of the confectioner's skill which bristle with bleached almonds. Some idea of the aspect of the living coralla of the members of this generic group may be gained by a reference to No. IV. of the coloured plates, in which the dominant hues of the component polyps are typically illustrated.

Among the more conspicuously tinted corals of this selected group, reference may be made to Nos. 8, 14, 16, 17, 19, and 28, representing the genera Seriatopora, Stylopora, and Pocillopora. The living coralla and associated polyps of the first two genera, in particular, usually vary in colour from the most delicate pale pink to brilliant rose, while in the third type, Pocillopora, a pale lilac or purplish hue prevails Typical illustrations of the corals and polyps of these several generic forms are included in Plate VII. of the coloured series. As there shown, they are seen to be very closely allied to one another structurally, the polyps in each genus being very simple, and furnished with but twelve symmetrical, knobbed, or capitate tentacles.

The only prominent form that remains unnoticed is the broadly expanded foliaceous example, No. 23, located near the centre of the immediate foreground. In shape and aspect it bears no inconsiderable resemblance to certain encrusting fungi. This species, *Podobacia crustacea*, agrees very nearly in the structure of its corallum and living tissues with *Lophoseris cristata*, included in Plate VIII. of the tinted series. In that species the ground hue of the general surface is usually light brown or a delicate lemon-yellow, and the radiating star-like polyps are pale apple or emerald-green.

Notwithstanding the extreme beauty of form and structure exhibited by the artificially-prepared corals that form the subject of this introductory plate, these exquisite fabrications of carbonate of lime, it will now be understood, represent but the whitened bones or skeletons of brilliant-hued living organisms. An intelligible analogy to the relationship that subsists between, and the comparative beauties that respectively characterise, these dry bones and the living polyps which they support, is afforded by their comparison with the more or less familiar lime-bleached skeleton leaves and floral envelopes that in former years enjoyed brief patronage for drawing-room decoration. The intricate lace-like traceries of woody fibre, of which these

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

CHARTED REEF, THURSDAY ISLAND, TORRES STRAITS.

vegetable skeletons consist, possess intrinsic features of beauty that in their special order can scarcely be surpassed, but are, at the same time, not comparable in hue and aspect with the same skeletal elements clad with their exquisitely-tinted living tissues.

PLATE II.

CHARTED REEF, THURSDAY ISLAND, TORRES STRAIT.

This first number of the series of reef-views, while by no means as attractive in aspect as many of the succeeding illustrations, possesses a specific value that claims for it a prominent position. It represents an area of reef, of the ordinary inshore or fringing variety, at the extreme south or seaward end of Vivien Point, Thursday Island, as exposed at an abnormally low spring-tide on June 9th, 1890. Throughout the greater portion of the year, including all ordinary springs and neaps, the larger portion of this coral-growing area is completely submerged.

It occurred to the author that this area, being situated in so readily-accessible a position, immediately outside the grounds of the Government Residence, Thursday Island, offered exceptional facilities for recording the much-needed data concerning the average rate of growth of the more important reef-forming coral species. Upon this subject there has hitherto been very little accurate information available. For the acquirement of such knowledge it is requisite that healthy coral-growths should, in the first instance, be selected; their respective dimensions and bearings with relation to one another should then be accurately determined, and corresponding measurements should be taken at systematic intervals. As an initial step in this direction, the author has made a rough diagrammatic chart of the vigorously-growing reef at the extreme outer edge of the area portrayed in the illustration now under notice. In this chart, the longest diameters of all the conspicuously-growing corals have been accurately measured and registered. An earnest appeal is here made, in the interests of science, to any residents in, or visitors to, Thursday Island, during favourable tides, to identify and measure these coral-masses, and by so doing to ascertain what growth they have made since their first measurement in the year 1890.

This diagram of the Vivien Point reef-area was first published in association with the author's presidential address to the Royal Society of Queensland for the above-named year; it is reproduced overleaf, together with a list of the specific forms of corals growing on it more detailed than has been previously recorded. This diagrammatically-charted area, with relation to the reef-view, Plate II., applies exclusively to the isolated islet to the extreme left of the reef, and is practically composed of two large coral-masses, separated from one another by a deep and narrow channel. The outermost, or larger, of the two masses consists of a solid growth of an exceedingly minute-celled Porites, identical with, or nearly allied to, *P. astræoides;* its characteristic nodular surface-pattern is distinctly visible on the inner right-hand border of the mass in the photographic reproduction. This Porites colony-stock in its longest, diagonal, diameter

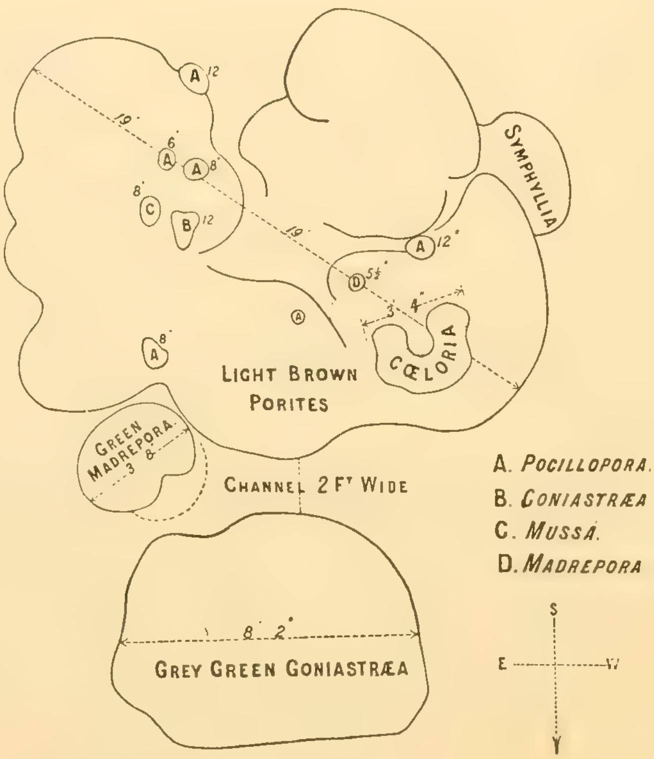


FIG I. *Ground Plan of Living Coral Masses at the extreme end of Vivien Point, Thursday Island, as exposed at lowest ebb of Spring Tide, June 9th 1890 The Area represented is identical with the point of the Reef to the extreme left in Plate II.*

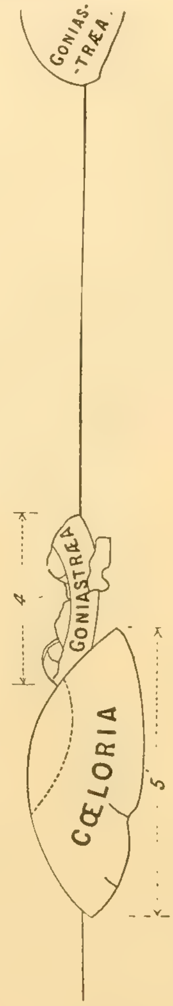


FIG 3. *Coral Masses to the left of those in Fig 2. Including a portion of the same Goniastræa-stock on the extreme right.*

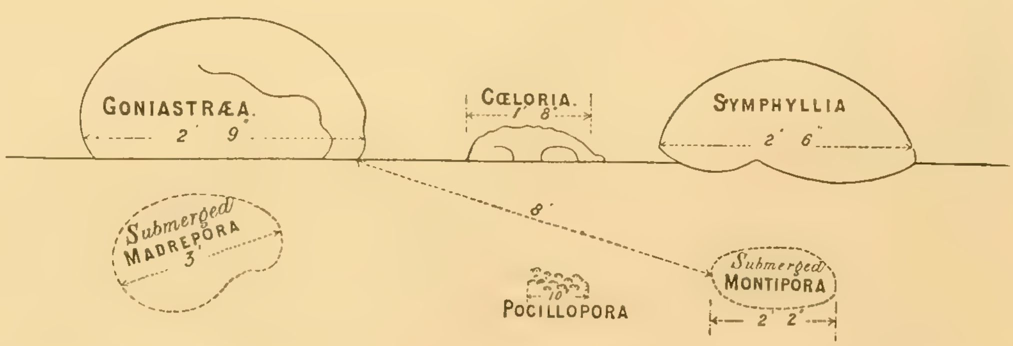


FIG 2. *Representing Measurements, at same date, of Foreground Corals in Plate II.*

DIAGRAMMATIC PLAN AND MEASUREMENTS OF THURSDAY ISLAND CORAL GROWTHS.

measures, as shown in the diagram, no less than nineteen feet. It is split up, on its seaward side, by two convergent intersecting gutters, and is separated on its northern, shorewards, face from the adjacent coral-mass by a channel over a fathom deep, which measured exactly two feet wide, at its narrowest point, when the two masses were awash at dead low spring tide.

Notwithstanding its present massive proportions and irregularity of contour, this huge Porites began as a small, symmetrically convex, corallum a few inches only in diameter, or, to be more accurate, from a single polyp of microscopic dimensions—from such a one, in fact, as is delineated among the representations of this genus included in Plate VIII. of the coloured series. The mind conjures up, intuitively, the number of the centuries that must most assuredly have elapsed since the primæval nativity of this gigantic coral.

In its present condition of growth, this Porites is living, and increasing in size, on its peripheral edge only, all vitality being arrested on its superior surface in consequence of its having attained to a vertical height that exposes it, periodically, to atmospheric influences inimical to healthy growth. This more elevated plane, although unfavourable to the further vertical enlargement of the Porites, is not unsuited to the growth of many other species, which are accordingly found flourishing on its dead horizontal surface. None of these superimposed corals were in June, 1890, of conspicuous size. The largest, a Cœloria, measured three feet four inches across its longest diameter, while the majority of the specimens, representing the several genera Pocillopora, Goniastræa, Mussa, and Madrepora, in no instance, as shown in the accompanying diagram, exceeded a width of twelve inches. A systematic record of the further growth of these comparatively young corals is specially recommended, and should elicit data of high interest and importance.

The second, more inshore, coral-mass indicated on the diagrammatic chart, is of smaller dimensions than the outer one, and measured but eight feet two inches in its longest diameter at the date recorded. It is also of a species distinct from that of the larger outside mass, being a Goniastræa, allied to *G. eximia,* in this instance greenish-white in hue, and having much larger constituent polyp-cells or corallites than the Porites. The channel separating these two contiguous masses was, as previously stated, at the date recorded, precisely two feet wide. It would be instructive to ascertain the time that will elapse before this channel becomes filled up by the growing corals, or otherwise what progress towards the accomplishment of such a result will be made within the next few decades. As indicated in the diagram, a symmetrical colony-stock of one of the procumbent species of Madrepora, *M. prostrata,* three feet eight inches in diameter, is interposed between the two main coral-masses, occupying a position to the extreme left of the intersecting channel. A smaller, more deeply submerged, growth of the same species projects yet further into this channel at the point indicated by the dotted line. This highly porous, loosely-branched species of Madrepora, it may be confidently assumed, spreads peripherally at a much more rapid

rate than the solid coralla of the Porites and Goniastræa. It may consequently happen, within the course of a few years, that this Madrepora shall have intruded so far into the dividing channel as to exert a material influence on the inwardly approaching growths of the two more massive genera.

One other coral-growth of conspicuous dimensions, included in the diagram, invites attention. This is a mass of the labyrinthine dark brown *Symphyllia hemispherica*, about three feet in diameter, which is growing on the south-westerly outer rim of the Porites. Its approximate size and position were duly charted; but the rapidly-rising tide intervened to prevent its precise measurement.

In addition to the outermost reef-area, roughly outlined in Fig. 1 of the accompaying diagram, careful measurements were taken, at the same date, of the longest diameters of the several conspicuous coral-growths that form the immediate foreground of Plate II. The dimensions of these more inshore coral-masses are indicated in Fig. 2 of the diagrammatic plan. They include, towards the left, an irregularly-rounded, almost high and dry, mass of *Goniastræa Grayi*, the commonest dark-brown species of a genus which enters so extensively into the composition of all inshore or fringing reefs throughout the Barrier district. This genus will be found most abundantly represented in the Palm Islands inshore reef, Plate IV., and also in the remarkable Skull Reef, illustrated by Plate XIV. The extreme right of the foreground is occupied by the dome-shaped corallum of one of the larger Brain-corals, Symphyllia, specifically identical with the specimen growing on the outer rim of the large Porites. Both this and the Goniastræa last referred to are, however, represented to much better advantage in the following plate.

Among the coral-growths in the present reef-view, yet unnoticed, attention may be directed to the smaller submerged Porites just awash in the central foreground, and having growing upon it a Pocillopora that is almost completely dry. So soon as this Porites attains a few more inches of vertical growth, its entire superior surface, it may be anticipated, will become dead and eroded, after the manner of the large outlying mass that forms the main element of the diagrammatically charted reef.

The third figure in the accompanying diagrammatic plan includes a couple of coral-masses that are located some twenty or thirty yards to the left, or east, of the foreground group in Plate II. They were photographed and measured at the same date, but do not embrace distinctive features requiring special illustration. It may be recorded, however, that the larger and nearer mass is a dark-brown Cœloria with very short calicinal valleys that appears to be identical with *Cœloria sinensis* (M. Ed. and H.), which, as shown in the diagram, has its upper surface obliquely weathered. The adjacent and hinder coral-stock represents a corallum of a Goniastræa that is eroded exteriorly and centrally in such manner as to exhibit a distinct crescentic outline.

A conspicuous feature, not hitherto referred to, in the central portion of the exposed reef in this photographic illustration, is the luxuriant development thereon of various species of

Alcyonaria. These include, immediately to the rear of the charted area, a considerable surface that is entirely encrusted with a corrugated-leather-like species, apparently identical with the *Alcyonium murale* of Dana, that is yet more extensively developed, and herein fully described, in association with the lower of the two reef-views included in Plate XX.

It remains to be mentioned that the high ground on the farther side of the water in Plate II. represents a portion of Prince of Wales's Island, with its scattered pearl-shelling stations. These landmarks should prove of service in making a re-survey of this reef-area. A like condition of the tide and the same bearings being accurately obtained, a photograph taken a decade or two hence should reveal important data concerning coral-growth in this region.

PLATE III.

ISOLATED CORAL-GROWTHS, CHARTED REEF, THURSDAY ISLAND.

This illustration represents a nearer view of the coral-growths that occupy the foreground of the preceding plate, but from an opposite standpoint, looking shorewards instead of seawards. The identical coralla of the Goniastræa and Symphyllia are here shown to much greater advantage, the minute individual cells of the former, and the elegantly convoluted ridges and valleys of the latter, being remarkably distinct. The life-colour of this individual Brain-coral was a rich golden-brown; it frequently happened, however, that while the septal ridges exhibited this golden tint the intervening valleys, or polyp-centres, were a rich velvety green. A fragment of such a more brightly-tinted variety is illustrated in Plate V. of the coloured series. Several coralla of the narrower-celled, ordinary Brain-coral occupy a somewhat lower level in this picture. The life-colours of these specimens were, when examined, lilac and brown, the former tint distinguishing the valley-like depressions, and the latter the intervening ridges. A coloured representation of this type is given in the plate last quoted.

A noticeable feature in Plate III. is the background, consisting of a mass of lifeless sedimentary coral-rock encrusted with growing Alcyonaria of diverse varieties. Towards the right may be observed the fleshy, lobulated polyparies of *Sarcophyton (Alcyonium) glaucum;* the middle ground is occupied by *Alcyonium flexibile,* and the left-hand area by the proliferous colony-stocks of a species of Ammothea. The extent of surface that may be covered by these soft-fleshed representatives of the coral class is even more abundantly demonstrated in several subsequent illustrations, including, notably, Plates XX. and XXI.

PLATE IV.

NO. 1.—INSHORE REEF, PALM ISLANDS.

This view is highly typical of the class of coral-reef that predominates on the intra-tidal areas of the Palm Islands group. It represents a portion of the foreshore that is left high and

dry with every spring-tide, and may be appropriately compared with an ordinary boulder-strewn beach on the British coast. Rock boulders are, however, here replaced by coral-stocks, while leathery, bright-tinted Alcyonaria growing upon them, take the place of the more familiar olive-brown seaweeds, or Fuci, of the British seas. The coral-masses thickly scattered throughout this reef-view belong almost exclusively to a single species of Goniastræa, very nearly allied to the form illustrated in the two plates previously described. Sprinkled here and there among the Goniastrææ, the somewhat larger-celled coralla of another Astræid, or star-coral, Prionastræa sp., may be detected. Two initial growths, or it may be the isolated, last surviving, fragments, of an original massive corallum of this variety are conspicuous near the summit of the much-eroded block towards the left in the immediate foreground. In life, as shown in Fig. 8 of Chromo plate No. V., the centre of each polyp-cell, or corallite, is brilliant grass-green, the surrounding septal ridges being dark brown.

The eroded block that forms the basis of these several coralla possesses an intrinsic feature of interest. Securely embedded within its substance, some half-a-dozen specimens of the so-called Frilled, or Furbelow, Clam-shell, *Tridacna compressa*, may be observed. The shells are usually pale yellow, while the membrane, or "mantle," of the living animal, exposed to view betwixt these slightly gaping "valves," is resplendent with a variety of the most gorgeous hues. Some idea of the life aspect of these Frilled Clams may be gained by a reference to No. XIII. of the coloured plates, in which the entire lower portion of the picture is devoted to a representation of some of the more characteristic tints and markings with which these Molluscs may be arrayed. Every gradation of shade, from palest turquoise to the richest ultramarine, and peacock-blue or green, variegated with black spots and scribblings, commonly obtain. In other instances the ground colour is purple or rich brown, brilliant green or blue spots and streaks taking the place of the black markings of the series first referred to. This frilled clam, in comparison with its huge relation, *Tridacna gigas*, found growing on the same reefs, but usually farther out to sea, is of relatively small dimensions, rarely exceeding a length of ten or twelve inches, those embedded in the worn coral-block illustrated measuring about six. The manner in which these clams become so deeply embedded in the coral-masses has been a matter of conjecture. Although the process has not actually been observed, it may be taken for granted that the clams anchor themselves in some small crevice of the corallum selected, at a very minute and early stage of their existence. The pressure of their hard valves acts as a check upon the ingrowth over them of the soft-fleshed, coral-secreting polyps; while, at the same time, it seems highly probable that, as in the case of many other shell-fish, they possess the property of eroding, or possibly of chemically dissolving, the dead coral matrix in their rear. On examining the picture with an ordinary hand-glass, one detects specimens of these clams established on many other coralla; and it is a moot point whether these shells do not contribute extensively towards the death and dismemberment of the corals upon which they have literally obtained a foot-hold. The encrusting Alcyonaria,

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ISOLATED CORAL GROWTHS, CHARTED REEF, THURSDAY ISLAND.

which hang in thick festoons over so large a number of the coralla, are, however, undoubtedly responsible for a very large share of the work of decay and disintegration.

The outer or seaward edge of this same Palm Islands reef, incorporating a much wealthier variety of coral-growths, finds characteristic illustration in several succeeding plates, among which Nos. VI. and X. may be specially referred to.

NO. 2.—ERODED INSHORE REEF, THURSDAY ISLAND.

This reef-view, at first sight, appears to embody but few points of interest, consisting for the most part of dead, much-eroded coral-rock, more or less encrusted with fleshy Alcyonaria, and the calcareous vegetable growths known as Nullipores. This picture is, however, of value, as it constitutes a highly characteristic illustration of a typical foreshore, or platform reef, at that point where the coral ceases to live, and where the rock-mass is almost exclusively composed of the consolidated *débris* of species formerly growing on the outer margin of the reef. A heap of these cast-up fragments, in their as yet unconsolidated state, may, in point of fact, be observed lying between the two large masses of peripherally-growing Goniastrææ that occupy the foreground. The higher (or back) portion of the picture represents, in other words, that plane of elevation where corals cannot exist, in consequence of its prolonged exposure to the sun and air with every ordinary ebb-tide. The vital phenomena of the Goniastrææ as depicted in this reef-view are, of themselves, highly interesting and instructive. In addition to illustrating the normal vertical growth limits of the species, it indicates the potentiality of the coralla to spread laterally to any unimpeded extent. The general aspect and plan of expansion of the coralla here illustrated may be said to constitute an epitomisation of the growth of the entire reef, pushing forward with vigorous energy on its outer edge, and leaving behind it a mass of loose or consolidated *débris* with scattered patches of semi-suspended vitality.

PLATE V.

NO. 1.—MADREPORA ISLET, PORT DENISON.

This exceedingly picturesque reef-view is typical of the coral-growth that predominates over a large area in the vicinity of Stone Island, Port Denison, on the North Queensland coast. Stags'-horn corals, belonging to the genus Madrepora, occupy a dominant position throughout this reef-scape, and are represented by several distinct species. The little islet in the central foreground comprises two varieties. The larger symmetrically ovate mass, *Madrepora decipiens,* is, as it grows, of a rich golden-brown hue, with whitish extremities. The smaller, irregularly-shaped

mass to its right, *Madrepora prostrata*, was bronze-green with yellow tips; but it is a species subject to much colour variation. An illustration of a small fragment of this species, in which the green is of a more vivid tone, is illustrated by Fig. 1 of Chromo plate No. IX. The adjacent figure in the same plate illustrates a showy variety of this species in which the corallum is bright shrimp-pink, with yellow terminations. A yet more slender, erect, profusely branching species of Stags'-horn coral may be observed growing in dense patches near the centre of the picture. This is *Madrepora pulchra*, remarkable for its attractive coloration. The main stem and branches are usually pale yellow, or buff-white; and each relatively large terminal cell, or "corallite," is either a delicate china or brilliant turquoise-blue. The polyps associated with these larger terminal areas are, by way of contrast, light emerald-green.

Among the few additional varieties discernible by close inspection in this reef-view, mention may be made of the encrusting, or foliaceous, coralla of a species of Montipora which varies through innumerable shades of purple, brown, and yellow. A large colony-stock of a golden-yellow variety with white edges may be observed in an almost completely submerged condition, immediately beneath the smaller of the two Madrepora masses, in the sub-central foreground group. Many patches of this same variety may be detected on the main body of the reef, and also, strewn over it, a considerable number of the rounded massive coralla of the cosmopolitan *Goniastræa Grayi.* Traversing this reef on foot, the author found innumerable mushroom-corals, Fungiæ, inhabiting the intervening pools; the majority of these belonged to a finely-toothed, small-tentacled variety, resembling *Fungia repanda.* A remarkable example collected on this reef, supporting no less than ten young coralla, is delineated in the upper figure of Plate XXIV. A coral that likewise occurs very abundantly in this locality is the cup coral, *Turbinaria cinerascens*, which forms cup-shaped or variously convoluted foliaceous coralla of a golden-brown hue, the relatively large polyps that build it up being brilliant yellow. Coloured illustrations of this generic type are included in Chromo plate No. VIII.

Although the time at the author's disposal did not permit of his making systematic measurements of selected coral-growths here, as at Thursday Island, this Port Denison area, which is depicted in the several succeeding reef illustrations, is readily accessible from the township of Bowen. These characteristic views might, consequently, be easily retaken by the camera, with such strict regard to the bearings and landmarks that the reproductions should fulfil the *rôle* of a measured survey, and thus assist towards ascertaining the future growth of the more conspicuous coral-stocks. It may be observed, in this relation, that the high land on the horizon of the present reef-view represents Gloucester Island; Cape Gloucester, on the Queensland mainland, being to the extreme right. Saddle-back Island, which was the scene of several of the subsequent reef-views, lies in the dim distance, midway between the above landmarks. It is faintly visible in the original negative, and may be just discerned in some of the photo-mezzotype reproductions.

NO. 2.—PORITES ISLET, PORT DENISON.

This reef-view, while belonging to the same district as the preceding one, represents an area in the immediate neighbourhood of Adelaide Point on the mainland. The very conspicuous central figure in this illustration is a grand mass of Porites, apparently identical with the variety that forms the basis of the Thursday Island diagrammatic chart. Like that example, its exposed, horizontal, surface is for the most part dead and eroded, vitality being visible along its lateral borders only. The manner in which the most recent growths have developed, forming projecting lateral crests, is worthy of note. As in the Thursday Island example, the eroded upper surface has been adopted as a fulcrum of attachment by various coral types that flourish on a higher vertical plane, or, in other words, are better capable of surviving atmospheric exposure than the Porites. Sub-spheroidal Goniastrææ and a corymbose Madrepora, *M. convexa*, represent the most conspicuous species in this instance. A more clearly-defined example of the Madrepora is included in the nearer foreground, while numerous coralla of the same species of Goniastræa are thickly crowded in the background towards the left. Such is the ovate symmetry and peculiar incidence of the light upon these Goniastrææ that, it transported to an ordinary landscape, they would pass for a flock of sheep.

A noteworthy feature in this Adelaide Point reef-area is the abundant development thereon of a luxuriant crop of seaweeds of the olivaceous or Melanospermous order. The weeds are of slighter structure than the ordinary European Fucaceæ ; but one dominant variety closely resembles the so-called Peacock-weed, *Pavonia padina*, of the British seas. An extensive crop of these algæ, mixed with coral growths, is conspicuous in the foreground of this Porites Islet reef.

PLATE VI.

NO. 1.—PORITES ISLETS, PALM ISLANDS.

This illustration represents a small portion of the outermost, tidally exposed, boundary of the reef whose inshore area has already been the subject of delineation and description. Two out of the three little coral islets included in this reef-view are, as in the preceding case, represented by a solid basement of *Porites astræoides*, or a very nearly allied form, upon whose eroded upper surface other coral species have become established. On the larger, or central, islet of the group, a considerable number of varieties may be recognised, including, most conspicuously, a finely-developed Brain-stone coral belonging to the genus Mæandrina. The Porites basement in these two larger islets were coloured brilliant mauve, the same tint characterising the majority of the massive coralla of this species throughout the Palm Islands district. A point of interest that attaches itself to this little islet group is the circumstance that, in their varying conditions of development, the respective islets may be said to epitomise the several most characteristic

coral-reef formations. In the largest (central) islet there is figuratively represented that commonest type of reef formation which consists of more or less elevated land,—here represented by the spheroidal coral-masses,—surrounded by a low platform or fringing reef. In the second (nearer) islet is typified the encircling or "barrier" structural plan, in which an outer wall of growing coral is separated from the "land" by a lagoon channel. The third islet, to the right, requires but slightly further central hollowing to become like a typical lagoon island, or atoll, reposing, as described by previous writers, like a garland on the surface of the water.

NO. 2.—PORITES AND MIXED SPECIES, PALM ISLANDS.

The area delineated in this illustration represents a portion of the Palm Islands reef lying midway between the isolated islets in the preceding plate and the foreshore reef that forms the subject of Plate IV., No. 1. The entire foreground and a large portion of the central-ground in this reef-view consists of a huge mass of Porites some thirty or forty feet in diameter, and having a depth of from two to three fathoms around its outer margin. Its growing edges, in this instance completely submerged, are eroded and broken up into the most irregular outline, though it may be surmised that in its pristine condition, long ages back, it presented the smooth symmetry and modest proportions of such a coral-stock as the spheroidal Goniastræa growing near the centre of its weathered horizontal plateau. A large colony of specific varieties have established themselves, and are flourishing, on this extensive plateau, including, in addition to the Goniastræa above referred to, a second species of the same genus, and numerous representatives of the several genera Mussa, Symphyllia, Cœloria, Mæandrina, and other Astræaceæ.

PLATE VII.

FRINGING REEF, PORT DENISON.

This reef represents one out of several of a series illustrating the characteristic aspect and composition of the fringing reefs skirting Saddle-back Island in the vicinity of Port Denison. The most noteworthy coral entering into the composition of this reef is the luxuriant growth of *Millepora alcicornis*, partly submerged, towards the right in the middle line. This species, as explained at length in the chapter specially dealing with coral organisms, belongs to a distinct order, that of the Hydrozoa, which is but rarely associated with a hard, calcareous skeleton or corallum. A second species, *Millepora ramosa*, is illustrated in Plate X., No. 1. It is a genus, however, that is by no means abundantly developed in the Great Barrier system, its zenith of development being associated with the tropical Atlantic or West Indian region. Other corals conspicuously represented in this reef-view include, near the central foreground, a large mass of a finely convoluted Brain-stone coral, Cœloria, having intercalated between it and the

picture margin the upper moiety of a corallum of *Pocillopora damicornis*. A second example of this last-named species occupies the centre of the reef-mass, with above, and a little to the right of it, a symmetrical colony-stock of the larger Brain-stone coral *Symphyllia hemispherica*. In the space between the Millepora and the Mæandrina a somewhat broken-up coral of a Prionastræa may be observed, belonging to that species usually distinguished, in life, by the brilliant green of its calicinal centres. Alcyonaria, and, as in one of the neighbouring Port Denison reefs previously described, brown Algæ, contribute to the surface garniture of this reef-scape.

PLATE VIII.

NO. 1.—DOG REEF, PORT DENISON.

This view, in association with the preceding and the subsequent pictures, belongs to the Saddle-back Island series. Its most remarkable characteristic, the one, in fact, that has won for it its distinctive title, is the remarkable resemblance that one of the included coral-stocks bears to a swimming dog. The position of this singular freak of Nature scarcely requires special indication, being so conspicuously visible in the guise of a white-bodied, black-nosed bull-terrier, with half-closed eyes, and depressed, shortly-cropped ears, making its way across one of the intervening channels So forcible is this likeness that it has been commonly mistaken for the object named by those who have seen the photograph. An equally (if not more) remarkable mimetic object-analogy will be found associated with the Skull Reef that forms the subject of Plate XIV. The dog-shaped coral-growth in the present reef-view represents, actually, a colony-stock of a Goniastræa, allied to *G. eximia*, with its upper surface just awash at the particular state of the tide when the photograph was taken. A second, large, irregularly-shaped, high-and-dry corallum of this species forms a prominent object near the centre of the picture on the outer edge of the reef. A noteworthy peculiarity of this coral variety is the fact that, after very short exposure to the atmosphere, on the fall of the tide, the polyps recede so far into the substance of the corallum as to be not only invisible, but to leave its surface pure white, or with only a slightly greenish tinge, as though completely dead and bleached. When first observed by the author at Thursday Island, these white coralla were supposed to be defunct; but on their re-inspection the following day under a higher condition of the tide the polyps were exserted, and in a vigorous state of vitality.

A species of coral included in this reef-scape, that has not entered into the composition of the views previously described, is the finely subdivided, spiked variety just raised above water a little to the left of the foreground centre. This is a species of Seriatopora, *S. elegans*, or *S. hystrix*, remarkable in life for its exquisitely delicate tints, which in the example referred to were a vivid rose-pink. Coloured figures of the corallum and polyps of this species are included in Plate VII. of the chromo-lithographic illustrations. A fine (in life, purplish) corallum of *Pocillopora*

damicornis occupies the centre of the same reef-mass, while a large, isolated dome of a golden-brown Brain coral, Cœloria, monopolises the nearest foreground.

NO. 2.—MILLEPORA AND ALCYONARIA, PORT DENISON.

This illustration represents, practically, a more comprehensive view of the reef delineated in Plate VII. The same coralla of Millepora, Symphyllia, and Cœloria, will be recognised in the centre of the picture, while new growths are included in both the background and the foreground of this central area. The isolated knoll, immediately to the front, supports a varied assemblage of coral species. Most conspicuous among these are the leather-like polyparies of *Sarcophyton glaucum*, which vary in colour from pale apple-green or bronze-green to lilac or golden-brown. These colours, as recorded in a later chapter, may change from time to time in the same individual polypary. Throughout all variations in hue of the leathery matrix, the essential living factors, or slender-stalked, eight-armed polyps, are, without exception, yellow, though exhibiting gradations of this hue that may range from palest primrose to the brightest cadmium. Illustrations of the diversely tinted polyparies of this Alycyonarian, together with its characteristic polyps, are included in the Chromo plate series, No. X. A few of the yellow polyps, in their semi-retracted state, may be distinctly discerned, with the aid of a hand-glass, near the lower edge of the polypary, situated farthest towards the left, in the uppermost group on this coral knoll. Closely associated, towards the back of this foreground mound, are coral growths which represent in the order of their disposition the genera Symphyllia, Pocillopora, and Millepora. The hemispherical mass that constitutes the main substance of this foreground mound would appear to be the long since dead, and much eroded, corallum of a giant Brain-stone coral, pertaining to the genus Cœloria.

The rocks in the background of this reef-view are of interest, though, unfortunately, somewhat out of focus. The attached objects which impart to those rocks a rough, nodulated appearance, are masses of the oyster, *Ostrea mordax*, of general occurrence throughout the Barrier district, and fully described and illustrated under the appropriate chapter heading. The interest attachable to these bivalves, in the present connection, is associated with the fact that their presence serves to illustrate the respective horizontal planes where the molluscs first appear, flourish, and cease to grow, the corals taking up the running. The most luxuriant growth-zone of this oyster species, it may be remarked, is represented by, as nearly as possible, half ebb of ordinary spring-tide. No corals are found growing at the vertical altitude of this mid-tide oyster plane; neither do the oysters descend to the coral zone. It will be obvious, from these remarks, that epochs of exceptionally low spring-tides are the only seasons in which these coral organisms can be approached for the purposes of study and photographic illustration under their natural conditions of vitality.

PLATE IX.

MADREPORE LAGOON, PORT DENISON.

The scene of this illustration is in close vicinity to that of the Madrepore islet that forms the subject of Plate V., No. 1. Throughout its extensive area, it presents an almost uniform growth of *Madrepora convexa*. Here and there, however, may be recognised the expanded foliaceous growths of a Montipora, nearly resembling *M. expansa*, and the more shrubby coralla of *Madrepora decipiens*. The shadowy, half-tone presentments of the totally submerged corals constitute a specially artistic feature in the original negative of this reef-view; but it is scarcely conspicuous in the reproduction. From a practical standpoint, this calm lagoon is worthy of notice, since it represents a typical example of those areas which abound among the reefs, and are particularly adapted for the artificial culture of mother-of-pearl shell, sponges, and other marine products of commercial value. The facility of access to this lagoon, and to innumerable others like it, from the port of Bowen, merits attention.

PLATE X.

NO. 1.—SUBMERGED MILLEPORA, PALM ISLANDS REEF.

The situation of this reef-view corresponds very nearly with that of Plate VI., No. 2. Its most noteworthy feature is the luxuriant growth of *Millepora ramosa*, visible in dense bush-like clumps immediately beneath the surface of the water, and for the most part rising from a depth of two or three fathoms. It represents the only area, with the exception of Port Denison, Plate VII., in which this Hydroid Coral has been found by the author to enter conspicuously into the composition of the Great Barrier Reef. This species may be readily distinguished from its Port Denison congener by the more slender, cylindrical, contour of its closely-crowded ramifications, and by its thick, bush-like habit of growth, as compared with the compressed palmate growth-plan of *Millepora alcicornis*.

Alcyonaria, of two specific varieties, including *Alcyonium glaucum* and *A. flexibile*, float loosely in the water to the extreme left, while immediately above them may be observed the irregularly-shaped corallum of a Goniastræa, into whose eroded base a number of Frilled Clams, *Tridacna compressa*, have wedged themselves, securing a firm anchorage. Among the variety of species scattered over the exposed surface of this reef there is one conspicuous type that has not yet been noticed. This specimen, which looks much like a spheroidal astræid with abnormally large polyp-centres, is situated on the farther margin of the reef, a little to the right of the precise centre. It is, as a matter of fact, an example of the dark-indian, or brick-red, species of Mussa, *M. corymbosa*, illustrated in Chromo plate No. V. A second, commoner, green or

green-and-brown, representative of the same genus, *Mussa multilobata*, occupies a position a little farther to the left. The coral of a dark hue and finely nodular structure, immediately to the rear of the eroded Goniastræa, is a golden-brown Porites belonging to that obtusely branching growth of which *P. furcata* is a typical example.

NO. 2.—LOPHOSERIS REEF, PORT DENISON.

The name associated with this reef bears reference to the fact that its basal mass is almost entirely composed of the foliaceous coralla of *Lophoseris cristata*, which has not been met with, in abundance, by the author, in any other part of the Barrier district. At first sight, the frondiferous coralla of this species appear to be of a weak, brittle consistence, unfitted to withstand the shock of the breakers or any other ungentle impact. As a matter of fact, the substance of the coralla is so dense, and the constituent laminæ coalesce with one another in such manner, as to form a reticulate, cellular mass of such strength and rigidity that walking upon it with the heaviest boots makes no impression. This anastomosing growth-pattern of *Lophoseris cristata* is most clearly shown, in the accompanying plate, in the almost totally submerged corallum situated a little to the left of the centre of the immediate foreground. The general colour of the living corallum of this characteristic species, of which an example is given in Chromo plate No. VII., is usually light buff-white, the radiating calicinal centres and associated polyps varying from pale primrose to bright emerald-green. There are two other species of corals distinctly visible in this Port Denison, Stone Island, reef-view, that have not been associated with any of those previously described. These include, to the extreme left, an irregularly developed corallum of a Galaxea, near *G. Esperi*, to which reference is made, and a characteristic illustration of a bleached corallum given in association with Plate I., Fig. 13. The second species, *Turbinaria cinerascens*, may be recognised as forming convolute, thickly-tuberculated folia, immediately underneath the entire nearer border of the wide-spreading corallum of *Madrepora convexa* that occupies the lower right-hand corner. This species, whose corallum is of a golden-brown hue, with bright yellow polyps, is abundantly developed throughout the Port Denison reefs. Coloured illustrations of this and other species of the same genus are included in No. VIII. of the chromo-lithographic plates. The symmetrical rotundity of the specimen of *Goniastræa Grayi*, perched on the growing mass of Lophoseris, is the only remaining salient feature that invites attention. For the type of artillery in vogue a century or so ago it would have made an excellent cannon-ball.

PLATE XI.

WARRIOR ISLAND REEF, TORRES STRAIT.

With this illustration begins the first of the series representing the typical Outer Barrier region in contradistinction to the inshore or fringing reef series to which all the previous

No. 1. INSHORE REEF, PALM ISLANDS.

W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

No. 2. ERODED INSHORE REEF, THURSDAY ISLAND.

views pertained. The coral growth in this initial reef-view is highly characteristic of the equatorial region to which it belongs. Warrior Island or Tud, as it is known to the natives, is situated in the parallel of 9° 50″ south latitude, the northernmost point of the associated reefs extending to within so short a distance as ten miles only, as the crow flies, of the New Guinea coast. The island, occupying the horizon-line to the extreme right of the photographic illustration, is of typical coral origin, elevated but a few feet above the level of high spring-tide, and having at its base a substratum of solidified coral *débris*. It will be shown, in the chapter dealing with the special subject of the Bêche-de-mer industry, that it represents one of the most important Queensland outposts for the prosecution of this extensive fishery.

The general facies of this Warrior Island reef is altogether distinct from that of any previously illustrated. The hummocky Goniastrææ, Mæandrinæ, and other Astræaceæ, invariably present in less or greater numbers throughout all the inshore or fringing reefs, are here conspicuously absent. In place of these, the coral-growing area is almost exclusively occupied by innumerable species of delicately-branching, resplendent Madreporæ. The luxuriant group that occupies the foreground on the right-hand side of the present reef-view is typical of the entire area. The symmetrical, bouquet-like coralla of *Madrepora millepora* represent the most conspicuous variety. The life tints of this species are remarkably beautiful ; the general ground tint being usually light buff or cream colour, while all the terminations of the crowded branchlets vary from a delicate lilac to the brightest mauve. The more shrubby specimen, in the immediate forefront of this group, is an example of *Madrepora hebes*, a species that abounds with numerous variations of growth and colour, throughout the Great Barrier district. The individual specimen above referred to, and the many other coralla of this species included in this reef-view, were of a rich seal-brown hue, with the exception of the growing apices, which were pure white. Not unfrequently the colony-stocks of this coral are brilliant green, sometimes green with lilac tips, or, again, a brilliant lilac hue throughout. Characteristic illustrations of this very variable species, together with a representation of its living polyps, are included in Figs. 13 to 15 of Chromo plate No. IX. As attested in the special Coral-Descriptive chapter, this species of Madrepora is not only subject to much local colour variation, but the characteristic tints of an individual corallum may alter within relatively short time-limits.

Intercalated among the corymbiform, or bouquet-shaped, Madreporæ in the group under discussion, a large short-spined sea-urchin, or echinus, *Sphærechinus australiæ*, may be discerned, though, to some extent, concealed by a mass of adherent seaweed. Although not visible in the illustration, the area it embraces abounded with other representatives of the Echinoderm class. Huge nodular, orange-and-red, star-fishes, *Oreaster nodosus*, of which an example is figured in Chromo plate No. XI., were thickly scattered over all the intervening (submerged) sandy tracts. Interspersed among them were numbers of the large Cushion-Star, *Culcita grex*, represented by Fig. 10 of the same coloured lithograph, whose aspect in the living state

may be aptly compared with pentagonal pin-cushions of various hues, thickly bedight with jewel-headed pins. In the example figured, the ground colour of the cushion was the much-admired old-gold, and the thickly studded pinheads were of that deep ultramarine-blue found, among precious stones, only in the lapis-lazuli.

It was on this reef-area, also, that that remarkable Holothurian, *Synapta Beselii*, was observed most abundantly, and of the largest dimensions. Many specimens as they lay outstretched in the pools measured over six feet long, and were usually variegated with mottled tints of pink and brown. A closely coiled-up example of this Synapta is represented by Fig. 8 of the Chromo plate No. XII.

Among the few corals, other than Madreporæ, distinguishable in this Warrior reef-view, reference may be made to the fine, somewhat cauliflower-like, corallum of *Pocillopora damicornis* immediately to the rear of the foreground specimen of *Madrepora hebes* that occupies the left-hand corner. A little to the right of the centre of the picture, one normally growing, and a second overturned, foliaceous corallum of *Montipora foliosa*, or a nearly allied species, constitute conspicuous objects. The life colours of the erect example were a deep violet, with creamy-white growing edges. An interesting coral, that requires a little more trouble for its detection, is situated to the left of the centre of the farther margin of the broad water space in the immediate foreground. The variety indicated is a species of Euphyllia, *E. rugosa*, which forms simply bifurcating tufts, a few inches only in diameter. The polyps in this genus are remarkable for their relatively large size and brilliant coloration, and are limited in their distribution to the most torrid, equatorial region, of the Great Barrier district. Plate IV. of the chromo-lithographic series is devoted more especially to the delineation of this generic group and its near allies. Among these illustrations, that example in which the polyp-tentacles are coloured lilac, with apple-green terminations, represents the variety visible in the reef-view. Should the reader possess the requisite patience, a small colony-stock of the Organ-pipe coral, *Tubipora musica*, will be discovered so growing that it forms the head of the small promontory that projects into the foreground water-space, near its centre, on the left-hand side. This interesting type, as demonstrated by a subsequent illustration, may fulfil an important *rôle* in the function of reef construction.

Another not very prominent, but at the same time interesting, coral-growth enters into the composition of this reef-scape. This is the variety represented by the small isolated cluster of digitiform terminations of a corallum that are exposed to view in the water-space on the extreme right-hand in the middle distance. This coral represents a species of Stylopora, agreeing in all essential details with the *Stylopora palmata* of Milne Edwards and Haime, and is remarkable in life for its usually brilliant coloration. In this example, the tint of the exposed branches was a bright magenta-pink, rendering it, as may be anticipated, a conspicuously attractive object, more especially when, as in this instance, the species was observed growing *in situ* for the first time. A coloured representation of this handsome species, including magnified figures of the minute rose-coloured polyps, is contained in Plate VII. of the chromo-lithographic series.

PLATE XII.

STAGS'-HORN REEF, OUTER BARRIER SERIES, NO. 1.

The preceding illustration, while characteristic of the Great Barrier Reef, pertains more essentially to its northern equatorial region. Plate XII. may be said to represent the first of the series that belongs specifically to the Barrier proper, as understood and resorted to from Cooktown, Townsville, and other of the North Queensland townships, for the prosecution of the Bêche-de-mer industry. The scene of this photographic illustration is close to Lark Passage, one of the principal shipping channels used by vessels plying between Cooktown and New Guinea.

As a reef-view it is unique. Almost the entire area is occupied by a luxuriant growth of the shrubby Stags'-horn coral, *Madrepora hebes,* the general aspect presented being not unlike that of a gorse-covered or heather-covered common. The life colours of the shrub-like coralla of this Madrepora plantation were not notable, as in some other instances, for conspicuous brilliancy, being chiefly of a warm brown hue with greenish-white terminations. Here and there, however, intervened colony-stocks of the same species in which brilliant green or lilac tints predominated. A bouquet-like growth of *Madrepora australis* occupies the centre of this reef-area, and a few coralla of *Pocillopora damicornis,* and more massive Astreaceæ, are sparsely scattered among the Stags'-horn thicket.

PLATE XIII.

(A.)—LOW WOODY REEF, OUTER BARRIER SERIES, NO. 2.

The scene of this illustration is the outer limits of the reef around Low Woody Island, a small coral-islet a little to the south of Lark Passage. On account of its convenience of access from Cooktown, and also to the most prolific Barrier fishing grounds, it is commonly utilised as a Bêche-de-mer headquarters fishing-station. The reefs around this islet, as exposed to view on the occasion of an abnormally low spring tide, have yielded some of the most varied and picturesque photographic reef-scenes that have been obtained. The wealth and variety of coral-species flourishing upon them is amply demonstrated in this and the five subsequent illustrations, which are all derived from the same locality.

The most conspicuous coral-growths in this first example of the Low Woody Island series are the widely-expanding, vasiform, coralla of *Madrepora surculosa,* two fine examples of which occupy the central ground on the right-hand side, while smaller coralla of the same species may be observed growing on many other more distant areas of the reef. The life colours of this species are remarkable for their delicacy. The basal portions of the short, thickly-crowded, central branchlets are usually of a light, pinkish-brown hue, with their terminations a more decided pink, while those

developed around the peripheral, or growing, edges vary in separate colony-stocks from pale lilac to primrose-yellow. Among other luxuriant coral-growths conspicuous in this reef-view, those of *Pocillopora damicornis*, a little to the right of the central foreground, and of *Madrepora australis*, of which a fine corallum occupies almost the immediate centre, are the most noteworthy.

(B.)—LOW WOODY REEF, OUTER BARRIER SERIES, NO. 3.

This reef-view, while delineating an area separated by a very short interval from that of the preceding illustration, includes a conspicuously distinct variety of coral species. The most prominent growths in this area are again referable to the genus Madrepora, but represent that loosely-branching, bush-forming section upon which the title of Stags'-horn corals is, *par excellence*, popularly conferred. *Madrepora hebes*, which monopolises so extensive a share of the Lark Passage view, Plate XII., reappears in this reef-scene, but accompanied by many additional branching species, including the elegant blue-tipped *Madrepora pulchra*, *M. secunda*, *M. muricata*, and other varieties. On the eroded Goniastræa, towards the right, may be observed a small corymbose colony-stock of *Madrepora Hemprichi*, whose ordinary life-tints are a rich cream-colour, with the terminal inch to each branchlet a brilliant lilac. A larger and more distinct illustration of this very handsome coral is represented by Fig. 20 of the bleached specimen group embodied in Plate I. *Pocillopora damicornis*, as in the preceding view, contributes extensively to the coral fauna of the present reef-scape, and is distinguished in life by its purplish or rust-brown basal stems and light lilac or fawn terminal branchlets. The white mass growing on top of the Pocillopora coral-stock, in the left-hand corner of the foreground, is an encrusting, flexible Alcyonium that threatens to envelop and suffocate the rigid coral.

PLATE XIV.

SKULL REEF, OUTER BARRIER SERIES, NO. 4.*

The *raison d'être* of the title associated with this reef-view scarcely requires elaborate explanation. At a first glance, and in default of further information concerning its coral nature, this scene might be interpreted to be the deserted battle-field of some titanic Mongolian horde, who had left behind them decapitated heads and grinning skulls as grim trophies of their desperate encounter. In the remarkably symmetrical headpiece lying near the front, the very dint that laid it low seems visible on its forehead, while, close against the lachrymal outlet of its right eye, reposes the unmistakable vestige of an unevaporated tear.

* In consequence of two Outer Barrier reef-views having had to make way for the introduction of other important subjects after copies of this and the succeeding plate were printed off, the original numbering associated with the titles has been accidentally retained. They should read, respectively, as Outer Barrier series, Nos. 4 and 5, in place of Nos. 6 and 7.

A not uninteresting point associated with this remarkable reef-scape is the fact that it was photographed, as was the case with the dog-like effigy in Plate VIII., No. 1, without the slightest suspicion, at the time, of the grotesque and gruesome elements introduced. Indeed, the Skull Reef area, here reproduced, occupies but a small superficies of the original negative, and it is by enlargement only that its suggestive peculiarities have been made prominent. In the matter of Coral-reef photography, primary regard has to be given to the well-worn aphorism, "Time and tide wait for no man." The lowest tidally-exposed coral-growths do not remain uncovered for a longer space, possibly, than half an hour; and in that brief interval the operator must crowd in all that he is able of rapidly-grasped eligible subjects, without wasting time over the comparison and selection of elaborate detail.

The coral species that enters into the composition of the skull-like effigies in the present illustration is a small-celled variety of Goniastræa identical with, or nearly allied to, *G. eximia*—a species whose corallum, similarly, when left high and dry, becomes almost white through the abnormal retraction of the associated polyps and their intervening membranes. Other members of the same family group of the Astræidæ are represented by the solid coralla of Prionastræa and a larger-celled variety of Goniastræa. The minutely nodular corallum of considerable size that occupies the centre of the reef, on the right-hand side, is a species of Porites closely related to *P. astrœoides*. The somewhat widespreading corymbiform or bouquet-shaped coralla of a species of Madrepora are pretty plentifully interspersed among the more massive Astræaceæ. These represent chiefly *Madrepora millepora*, the growing colour of which, as with several allied forms, is a creamy-buff with brilliant mauve-pink terminations to each of the erect, crowded branchlets. In many specimens it was observed that the rims of all of the more prominent lower corallites were similarly tinged with the brighter colour; the distal terminations of some of the dried coralla of this Madrepore collected have retained a considerable increment of their original tint.

Alcyonaria of diverse varieties enter extensively into the composition of this reef-view. Among these, the most notable species is the one of a white colour and frothy aspect that covers a large space near the outer margin of the reef to the extreme left. The natural tint of this species is a pale primrose-yellow, and it is identical with the type delineated in Fig. 2 of Plate X. of the chromo-lithographic series.

PLATE XV.

LOW WOODY REEF, OUTER BARRIER SERIES, NO. 5.*

This reef-view, from an artistic standpoint, lays claim, perhaps, to the most prominent position among the collective series reproduced in this volume. The variety of coral species it

* See Footnote to Preceding Plate.

embraces, their promiscuous plan of intermixture, but, at the same time, separation into distinct groups by intervening water-spaces, combine to form what may be denominated a well-balanced picture. The coral patch on the right-hand side of this reef-scape is noteworthy for its luxuriant growths of Stags'-horn Madrepores, which embrace, in the immediate foreground, three or four separate species, distinguishable in their living condition, not only with reference to their relative dimensions and contours, but also by their diverse colouring. The most robust species, having only a few simple bifurcations elevated above the surface of the water, represents that more massive form of *Madrepora decipiens* which is delineated on Plate IX., Fig. 5, of the chromo-lithographs, whose living tints, as there indicated, are not unusually pale primrose-yellow throughout, with the exception of the terminal-growing inch, which is a delicate rose-pink. To the rear of this larger species is a denser clump of the finely-branching form *Madrepora pulchra*, having the larger terminal calicle of each branchlet turquoise-blue, while the remainder of the corallum is straw-colour or light buff. A little to the rear of these occur the branching coralla of *Madrepora hebes* and *M. secunda*, the former, in this instance, being a rich brown with white growing tips, while the latter, as in the small fragment reproduced in Chromo plate IX., Fig. 7, is coloured throughout an intense violet. Luxuriant growths of *Madrepora millepora*, noticed in association with the preceding plate, two or three massive Astræaceæ, and a remarkably fine hemispherical colony-stock of *Pocillopora damicornis*, represent the remaining most prominent coral varieties on the right-hand side.

The more extensive, irregularly broken-up coral patch towards the left contains but few visible specific varieties that are not represented in the right-hand section. The outlying strip in the farthest distance is noteworthy as being composed almost exclusively of an unmixed growth of *Madrepora hebes*. The most interesting feature on this side, however, is the large Frilled Clam, *Tridacna compressa*, snugly ensconced on the lee side of the Goniastræa in the immediate foreground. This very fine example of the species measures about one foot in length. A younger and much smaller specimen of the same bivalve may be observed, though not very distinctly defined, embedded in a crevice towards the left in the upper surface of the same coral mass. The gorgeous colours of the exposed mantle-surfaces of these mollusca have already been a subject of comment in association with Plates IV. and VI.

PLATE XVI.

CRESCENT REEF, OUTER BARRIER SERIES, NO. 6.

Low Woody Island again supplies the material for this reef-scape. It illustrates, undoubtedly, the most luxuriant expanse of living coral (condensed into a relatively narrow area) that the author has had the good fortune to photograph. The genus Madrepora, as is distinctly evident, enters most extensively into the composition of this reef. Conspicuously to the front, on the left-hand

No. 1. MADREPORE ISLET, PORT DENISON.

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

No. 2. PORITES ISLET, FRINGING REEF, PORT DENISON.

side is flattened, widely-expanding corallum of *Madrepora surculosa.* Many other coralla of this variety are visible on the reef, and notably a large isolated example well out to sea, near the centre of the picture. Growing at a lower level than, and a little to the right of, the foreground specimen, is a semi-submerged corallum of *Madrepora gemmifera,* a species conspicuous for its brilliant and varied tints. In some examples observed the corallum was bright violet throughout, with a tendency to magenta towards the tips of each separate branchlet; in others a creamy hue predominated, with violet or crimson extremities and growing points; while in a third series, the ground colour varied from light to dark sage-green, all the growing points, as in the preceding instance, being violet or crimson. Two of the digitiform branchlets of this species, embodying the conspicuous colour-variations last mentioned, are represented by Figs. 9 and 10 of the Chromo plate No. IX.

The numerous other specific varieties of this same genus that are visible on this reef include, among the bouquet-shaped corymbiform series, *Madrepora australis, millepora, digitifera,* and *Hemprichi.* Of the bush-forming, or Stags'-horn varieties, a luxuriant growth is conspicuous along the inner margin of the reef. The most massive coralla of this series, near the foreground centre, represent *Madrepora grandis,* a species of which the ground colour is commonly bright yellow. A variety, of a light straw hue, with delicate lilac terminations, was obtained at the Palm Islands. A small terminal branch of the more ordinary yellow corallum of this species is included in the coloured plate last quoted. The very massive proximal, or basal, ramifications of this robust coral may be as much as three inches in diameter. *Madrepora decipiens, muricata, hebes, pulchra,* representing forms enumerated in association with previous illustrations, assist to swell the list of specific types that flourish on this luxuriant reef. The genus Pocillopora is abundantly represented in this reef-view, by the cosmopolitan variety *P. damicornis;* a few coralla of massive Astræaceæ are also visible. Among the latter, an abnormally smooth, hemispherical corallum, probably that of a Cyphastræa, occupies a central position on the reef, a little towards the right.

PLATE XVII.

CRESCENT REEF, OUTER BARRIER SERIES, NO. 7.

This reef-scape represents an end-on view of the outermost portion of the area included in the preceding plate. On comparing the two, several of the more prominent coral-stocks will be recognised as occupying conspicuous positions in both pictures. The hemispherical sub-central Cyphastræa is one of these, and also the fine corymbiform corallum of *Madrepora australis* that forms the principal coral-growth on the left-hand side of the immediate foreground. An enumeration of the associated varieties would be but a repetition of the description of the preceding plate. There is one, more diminutive, thickly branching species of Madrepora, however,

discernible in this nearer view of the same reef that has not been previously noticed. This is *Madrepora rosaria*, var. *dumosa*, of which a highly characteristic illustration is given among the bleached coral specimens illustrated by Fig. 18 of Plate I. of the photographic series. The life colours of this variety are usually olive-green, with the exception of all the terminal "cells" and growing points, which, together with the associated polyps, are, by way of contrast, pale primrose. In the more robust normal growth of this species, represented by Figs. 2 and 5 of the plate last quoted, the ground tint is commonly flesh-pink, and all the terminal corallites and growing apices are white or pale yellow.

PLATE XVIII.

ORGAN-PIPE CORAL REEF, THURSDAY ISLAND.

The interest attached to this illustration is associated with the fact that all the coral-growths visible upon it are those of the so-called Organ-pipe or music-coral, *Tubipora musica*. This well-known species belongs to the group or order of the Cœlenterata, which is technically distinguished by the title of the Alcyonaria. All its members, as explained in a special chapter, differ from the ordinary stony-corals, or Madreporaria, in respect that their polyps invariably possess eight tentacles only, in place of the twelve, or of the very much greater number found on all Madreporarian polyps. These eight tentacles of the Alcyonarian polyp are, moreover, in most instances, distinctly fringed or pinnate. The majority of the Alcyonariæ are characterised by their association with a more or less flexible polypary, and, as far as they occur on exposed reefs, they usually take the form of encrusting or lobulate masses of various patterns, certain of which have been previously referred to. The Organ-pipe coral is unique of its kind, it representing, with but one exception—the Blue coral, *Heliopora cœrulea*, figured and described in connection with the next succeeding plate—the only type of its class that develops a rigid corallum. This corallum consists of an irregular nodular mass of closely associated calcareous tubes of a deep crimson hue, which are bound together vertically by transverse plates, of the same substance, in such manner as to present a highly suggestive resemblance to the pipes of an organ with the supporting platforms. The polyps of the living corallum of *Tubipora musica* are a pale emerald-green, and have their eight tentacles very distinctly fringed. The photograph of a corallum of the natural size, with its polyps expanded, is reproduced in Plate XXVI., while a small fragment of the same coral, with the associated life colours, is included in Plate X. of the chromo-lithographic series.

It may be observed of the Organ-pipe coral that, in common with other more ordinary Alcyonaria, it flourishes in areas where there is less tidal scour, and consequently more sedimentary matter, than is favourable to the growth of the typical reef corals. As a matter of fact, both here and in most other places where this type was observed, the coralla were

more or less covered with a fine alluvial deposit. It has been previously remarked that this species is represented in the present reef-area to the exclusion of all other coral varieties. Scattered over the surface of the exposed reef, there is, at the same time, a thick sprinkling of tufted algæ ; while, projecting above the surface of the water in the farther pools, may be observed the projecting tips of the broad-bladed, grass-like, Zostera, or an allied plant, which constitutes the favourite food of the Dugong.

The re-identification of the scene of this photographic view, with the included corals, can be easily accomplished in association with the conspicuous landmarks. The extensive foreground area represents a portion of the low foreshore at the back, or east side, of Thursday Island. The high ground that constitutes the entire horizon is a part of Hammond Island, recently brought into prominent notice through the discovery of conspicuous gold deposits ; and the small islet in the middle distance is an ancient aboriginal burying-site, known as Dead Island.

PLATE XIX.

ALCYONARIAN REEF, THURSDAY ISLAND, NO. 1.

This photographic reproduction has been selected with the object, generally, of illustrating the remarkable extent to which Alcyonarian corals may fulfil the *rôle* of reef investiture, and for the purpose, specially, of indicating the natural aspect *in situ* of that most interesting representative of the order, *Heliopora cœrulea.* In relation to the general presentment, it may be observed that there is scarcely a spot throughout the area photographed that is not occupied by an Alcyonarian polypary. Close against the foreground, on the right-hand side, lies the disintegrated corallum of a defunct Madrepora. These, together with the traces here and there of a basement of more massive, lifeless, coral blocks, indicate that this was originally a luxuriant coral area that has been invaded and gradually smothered off by the insidious Alcyonaria.

Several specific varieties of these fleshy representatives of the coral class may be recognised in this picture. The most conspicuous type is the one with large, obtusely-lobed polyparies, somewhat resembling elephants' feet in contour, that occupies the centre of the reef-area, and spreads obliquely down towards the left. This species, which received brief notice in association with Plate VIII., No. 2, is apparently identical with the *Sarcophyton (Alcyonium) glaucum* of Dana. As previously remarked, the polyparies vary in tint from glaucous or verdigris-green to golden-yellow or brilliant lilac, and may even change their tints individually within a few days. In their young, initial condition, these irregularly-lobate polyparies are, as in the illustration given in Plate X. of the coloured series, simply mushroom-shaped or peltate. The innumerable polyps, whatever may be the tint of the associated polypary, are invariably bright yellow in hue and mounted on long, highly extensile and contractile footstalks. The second species of Alcyonium, which occupies

the immediate central foreground, and the greater portion of the posterior area of the reef, differs from the preceding type in the more profusely divided, digitiform, prolongations of the peripheral edges of its polyparies. Its customary line tints are varying shades of lilac; it would appear to be identical with the *Alcyonium flexibile* of Dana. A third, but as yet undetermined, species of the same genus forms two slightly separated patches to the extreme left of the centre and the background of this reef-view. It presents, in life, the appearance of closely crumpled leather of a golden-brown hue, and is apparently identical with the species illustrated by the lower figure of the following plate, and there associated with the title of *Alcyonium murale*.

The so-called "Blue coral," *Heliopora cærulea*, of which a fine corallum is stationed in the centre of the near foreground, while a younger growth may be detected farther to the right, well merits the place of honour that it adventitiously occupies. The high interest attached to this species, as the only known living representative of the Alcyonarian order that fabricates a solid calcareous corallum, together with all essential data concerning its structure and affinities, is fully dealt with in the chapter that is devoted specially to coral organisms. In the Organ-pipe coral, Tubipora, which constituted the subject of the preceding plate, the corallum, while rigid and calcareous, is formed out of thin, loosely aggregated tubuli, while in the present form, Heliopora, it is as dense and ponderous as that of a Porites. The popular name associated with this species is derived from the deep indigo-blue colour of its internal substance as exhibited in sections when snapped asunder. The exterior surface is usually of an unattractive light slate, or bluish-grey hue; but in some instances the distal growing edges are light yellow. This lighter colour is very distinctly indicated in the luxuriantly growing corallum included in this reef-view, while an illustration of the natural lines of the corallum, and the aspect of the constituent polyps, is embodied in Figs. 1 and 2 of Plate X. of the chromo-lithographic series.

A very characteristic representative of the same Alcyonarian class remains to be noticed in association with this reef-view. The species referred to forms incrusting masses of sub-cylindrical or clavate polyps of semi-cartilaginous consistence that are closely united to each other by a reticulate, or intricately interlacing, basal rhizome. This species, which appears to be closely allied to *Clavularia viridis*, will be found represented by a large reticulated mass to the extreme right of the nearest foreground, other, less distinct, colony-stocks being recognisable at farther distances to the rear in the same straight line. In the condition illustrated by this reef-view, all the polyps are necessarily contracted. In their submerged condition, when fully expanded and associated together in dense clusters, they present an exceedingly beautiful spectacle. The individual polyps, as shown in Fig. 17 of the Chromo plate No. X., are of considerable size, and each of the eight tentacles is profusely clothed with brilliant golden-green pinnules. As the polyps are massed together in such numbers that their individuality is indistinguishable, the expanded colony-stocks present an aspect that may be most appositely compared with luxuriant tufts of some very brilliant hypnoid moss. This Clavularia appears to be confined to the equatorial

regions of the tropics, being especially abundant in the vicinity of Thursday Island, but apparently absent on the reefs visited south of Torres Strait. The scene of this particular view, which embraces so rich a collection of Alcyonaria, is the Madge Reef, laid bare at spring-tides only, in the channel that separates Thursday and Prince of Wales Islands.

PLATE XX.

(A.)—ALCYONARIAN REEF, THURSDAY ISLAND, NO. 2.

The site of this reef-scape is adjacent to that of the preceding one, being situated on an extremity of Madge Reef, with portions of Thursday and Prince of Wales Islands visible on the right and the left hands respectively. As in Plate XIX., the Alcyonaria monopolise the largest share of the exposed reef. A few stony corals, including, towards the central foreground, two or three spreading coralla of *Madrepora prostrata*, and a depressed, symmetrically ovate one of a species of Cyphastræa, are the most conspicuous members of their order. Among these, the Madreporæ, almost without exception, already indicate the presence of parasitically attached Alcyonarian polyparies, and are, in consequence, threatened with early extinction.

The species of Alcyonaria recognisable on this reef include the two types, *Sarcophyton glaucum* and *Alcyonium flexibile*, associated with the preceding illustration. There is also an extensive growth of a species, having a minutely nodulated polypary, that is apparently referable to the genus Ammothea. The most remarkable representative of the Alcyonarian order visible in this reef-scape is undoubtedly, however, the symmetrical form, several feet in diameter, with unilaterally-lobate radial plications, that fills a large area of the foreground on the left-hand side. In its general contour the polypary of this species appears to coincide very nearly with that of the *Alcyonium latum* reported by Dana from Fiji, with the name of which it is provisionally associated. In the Thursday Island example the polypary was coloured a rich golden-brown, while that reported from Fiji was green. A corresponding, or even greater, difference of tint may, as already recorded of *Sarcophyton glaucum*, obtain among individuals of the same species.

(B.)—ALCYONARIAN REEF, THURSDAY ISLAND, NO. 3.

This picture, also from the Madge Reef, Thursday Island, graphically illustrates the remarkable development to which an individual Alcyonarian polypary may attain. From the foreground to the water's edge in the middle distance, a width of at least fifty or sixty feet, the entire superficial area is encrusted by one continuous rugose polypary of the *Alcyonium murale* of Dana. In its course of growth this polypary has, as evidenced by the local irregularities, overgrown many Madreporarian coralla, and it is as assuredly advancing against, and even beginning to encroach

upon, and overwhelm, the several masses of living Goniastrææ that are conspicuous in the left-hand corner of the foreground. In aspect and colour this remarkable Alcyonarian bears a striking resemblance to coarsely-corrugated, newly-tanned leather. The polyps associated with this gigantic polypary are identical in form, size, and colour, with those of *Sarcophyton glaucum*, illustrated by Figs. 18 and 18A of Plate X. of the chromo-lithographic series. The total number of polyps contained in the continuous polypiferous encrustment embodied in this reef-view presents a problem whose solution would entail the registration of a portentous array of figures.

PLATE XXI.

GIANT SEA-ANEMONE, DISCOSOMA HADDONI.

It will be readily comprehended that the anemone which forms the subject of this illustration is a very giant of its class, in association with the record that examples have been met with by the author in which the expanded disk measured no less than from eighteen inches to two feet in diameter. It is tolerably abundant throughout the Barrier district as far south as Flat Top Island off Mackay, occurring chiefly in the shallow pools at about half or three-quarters ebb. A characteristic feature of this species is the contour and aspect of the tentacles. When the anemone is fully extended and in complete repose, its disk presents the appearance of being covered with minute, perfectly spherular, bead-like papillæ, which are distributed thickly on the periphery, and in gradually attenuating linear series towards the central mouth. On closer examination the spherular papillæ are found to be mounted on short footstalks, these structures, as a whole, corresponding morphologically with the subulate tentacles of all ordinary sea-anemones. The slightly elongate and distinctly capitate contour of these modified tentacles may be recognised towards the superior, right-hand, margin of the periphery of the photographic reproduction, where a number of these organs are slightly pressed to one side. The almost globose shape of the tentacles, in their condition of fullest expansion, is not represented in this illustration in as marked a degree as frequently obtains. The anemone, when photographed, had been kept in a basin, with frequently-changed sea-water, for several days, and was in a somewhat abnormally puckered-up, contracted state. It is only towards the lower peripheral border, indeed, that any of the tentacles present a near approach to their fully-extended appearance.

A more adequate idea of the characteristic aspect of the tentacles of this anemone in their normal condition of inflation may be obtained by a reference to Plate II. of the coloured series, and in which segments of the disks of two diversely-coloured individuals are delineated in their natural size. It will be observed that a brilliant-hued fish and a crustacean are included in this coloured plate. These both represent what are known technically as "commensal" species; they live on the most intimate terms of friendship with the anemone, swimming freely in and out of its mouth, and making its body or somatic cavity a harbour of refuge into which they adroitly retreat

on the near approach of any hostile object. The fish represented in this association is one of the Pomacentridæ, *Amphiprion percula*, and the crustacean a prawn, apparently referable to the genus Palæmon. It is remarkable that these commensal representatives of two distinct zoological classes are similarly tinted, although in the case of the prawn the white ground colour is so transparent that its red and yellow spots only are visible as the animal swims. The two organisms, it is perhaps desirable to explain, are not found inhabiting the same individual anemone. This highly interesting subject of commensalism receives fuller attention in the chapter that deals specially with coral organisms.

A feature worthy of note in association with the photographic illustration of this fine anemone, given in Plate XXI., is the presence in various areas of the disk, but notably immediately below the central mouth, of small, white, thread-like patches. These at first sight are liable to be mistaken by zoophytologists for the protruded "acontia," or thread-cells, so highly characteristic of many species of British sea-anemones. As a matter of fact, they are "craspeda" only—structures of an analogous nature that similarly enclose innumerable stinging cells, "cnidæ,' but that are not capable of independent protrusion and retraction through special openings "cinclides," in the body wall. In their normal condition these craspeda form, as it were, binding cords to the free edges of the mesenteric tissues, and it is only through forcible rupture, or erosion of the integument, that they make their appearance, as here shown, on the surface of the disk. Another point of interest noticeable in this illustration is the presence of distinct eminences along the outer or distal border of the reflected inferior or aboral surface of the disk. These prominences are of a wart-like aspect, and resemble the tentacula of the superior surface in a state of extreme retraction. They possess a more or less adhesive function, and their presence in this form demands recognition as constituting an essential diagnostic feature.

It not having been found possible to identify the species now under consideration with any previously-described kind, the author has bestowed upon it the title of *Discosoma Haddoni*. The specific name is given by way of compliment to Prof. A. C. Haddon, of the Royal College of Science, Dublin, who has added much to our knowledge of the anatomy of the Anthozoa generally, in addition to having collected many of the species illustrated in this volume during his recent explorations in Torres Strait.

PLATE XXII.

STINGING ANEMONES, ACTINODENDRON AND MEGALACTIS.

The anemones illustrated in this photographic reproduction present a remarkable contrast to the form delineated in the preceding plate. In place of the large disk and the simple, stunted, sub-spherical tentacles, we here have elegant ramifying structures of extreme complexity that extend a long distance on every side beyond the peripheral border. Both species

are remarkable for their stinging or urticating properties, the form represented by the upper figure being most notable in this respect. The urticating property possessed by this type, as personally tested, is nearly as powerful as that of an ordinary stinging-nettle, and the rash produced on the skin through contact with the animal's stinging-cells or "cnidæ" endures for several days. The habits of this sea-anemone are very distinct from those of the succeeding type, as it occurs most abundantly in the pools of water left on the sandy flats at half or even one quarter ebb. The crown of tentacles, which only is visible in the accompanying plate, surmounts an elongate, highly-contractile stalk, or column, penetrating the sand for eighteen inches or more, and affixed to some rock or dead and buried coral boulder. The attempt to dislodge the animal from the supporting fulcrum is almost invariably vain; and, in order to secure specimens without mutilating their elaborately branched tentacular crown, the plan was resorted to of thrusting a sharp knife as far as possible down the side of the column and there cutting it abruptly through. The photograph of the form here reproduced was taken of the zoophyte while basking *in situ* in a sand-pool at Somerset, in the Albany Pass, the narrower, but since the *Quetta* wreck most commonly adopted, entrance to Torres Strait for vessels passing north from Queensland ports.

Some difficulty has been experienced in identifying this species with any previously described form; the only one in which its essential features are to a certain extent symbolised being in the very crude illustration and description of *Actinodendron alcyonoideum* of Quoy and Gaimard, contained in the "Voyage a l'Astralabe," 1833, with which type, in preference to multiplying specific titles, it has been thought advisable to allocate it. In this decision the author is supported by Prof. A. C. Haddon, to whom this illustration was submitted, and by whom the same species has been obtained from an adjacent locality.

The life colours of this Actinodendron, compared with those of many other members of its class, are lacking in brilliancy, being chiefly represented by varying shades of light brown and white, which are probably conducive to its advantage by assimilating it to the tint of its sandy bed. When fully extended, the compound tentacles are elevated to a height of eight or ten inches, and bear a remarkable resemblance to certain of the delicately branching, light-brown seaweeds that abound in its vicinity.

The lower of the two figures in Plate XXII. represents a species which at first sight possesses much in common with the foregoing form. The tentacles are, however, relatively more elongate and more regularly pinnate, while the termination of each minute, ultimate, subdivision is perfectly simple, in place of being distinctly bifid. In respect to their plan of ramification, the tentacles of this anemone accord with that structural type which, in a moss or fern frond, would be termed by botanists "tri-pinnate," each primary pinnule being further subdivided into secondary and tertiary pinnulæ. In the preceding figure of *Actinodendron alcyonoideum* it is conspicuously manifest that the primary and secondary subdivisions of the tentacles, in place of

No. 1. PORITES ISLETS, PALM ISLAND'S REEF.

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

No. 2. MIXED CORALS WITH PORITES BASEMENT, PALM ISLAND'S REEF.

exhibiting a pinnate plan of disposition, subtend from every side of their central axis, more nearly approaching, in this respect, a verticillate form of growth.

In respect to their obvious pinnate character, the tentacles of this species more nearly resemble those of a Phymanthus, of which genus a typical variety is included in Plate III. of the coloured series. This fact has been recognised by Prof. A. C. Haddon, to whom the photographs were submitted, and who, in the first instance, was inclined to identify it with a species, also obtained by him from Torres Strait, upon which he has proposed to confer the title of *Phymanthus muscosus.* The relatively few tentacles, twenty-four only, possessed by this type preclude, however, its admission among the typical Phymanthi, and a further consultation of the older works of Zoophytology has determined the author upon relegating it, provisionally, to the genus Megalactis of Ehrenberg. As a hitherto undescribed species of that genus, it is associated in this volume with the title of *Megalactis Griffithsi;* the specific name adopted being conferred by way of compliment to Sir Samuel Griffiths, the eminent Queensland statesman, to whom this work is dedicated.

The habits of this new Megalactis differ in a marked manner from those of the preceding species. Instead of inhabiting sandy flats or tidal pools, in the full glare of the sun, it prefers the shelter of some rocky or coral boulder. Its column does not penetrate deeply beneath the surface, and it can be detached with comparative ease from its chosen fulcrum. The tentacles are usually a clear brown or French grey, with a distinct pale greenish stripe running up their centre. The central disk is distinctly marked with radiating lines that correspond with the subjacent mesenterial divisions, which, as clearly shown in the accompanying photographic reproduction, present distinct features that accord with their corresponding mesenterial cycles. Thus, those that overlie the primary developmental cycle are plainly indicated by the six longest and thickest white lines that radiate from the stomadæum or oral aperture; those representing the second developmental cycle are as clearly defined by the six shorter white lines, intervening between the six primary ones, that do not reach the margin of the mouth. The two nearer of those secondary radial lines are somewhat obscured by the tentacular ramifications. The lines corresponding with the sub-division possessed by the three combined mesenteric cycles are represented by the twenty-four finer and more variegated lines that extend from between the outer ends of the preceding twelve lines to the extreme edge of the periphery. In consequence of the thickly intervening tentacular sub-divisions, only some half-dozen elements of this peripheral linear series are conspicuous in the photographic reproduction. It is, finally, worthy of note, that the lip of the siphonoglyphe or gonidial groove is clearly represented by a narrower indentation at the upper angle of the mouth or stomadæum. The fine specimen that furnished the subject of this illustration was photographed on the Warrior reef, in Torres Strait.

PLATE XXIII.

MUSHROOM-CORALS, FUNGIA CRASSITENTACULATA.

This plate illustrates the life aspects of one of the so-called Mushroom-corals, *Fungia crassitentaculata*, in various states of expansion, contraction, and development. The large, fully-expanded example on the left, and the contracted specimen forming the lower figure on the right-hand side, represent the same individual coral, photographed within a few minutes' interval. In this last-quoted illustration, the entire outline of indurated calcareous corallum is conspicuously visible, and the close association of each contracted tentacle, with the inner, centrally abutting, end of its corresponding septal element, may be also distinctly traced. The expanded example on the left, excepting in one minute area, exhibits no trace whatever of its coral skeleton. Unaccompanied by an explanation, it might be pardonably mistaken by those familiar only with the Cœlenterata of the British seas for a fine specimen of the so-called Dahlia-anemone, *Tealia crassicornis*. A photograph of this familiar species recently taken by the author in a rock-pool on the Devonshire coast might, in point of fact, have been almost indistinguishably substituted for the present illustration. The life-colours of this Mushroom-coral, however, vary in a direction that is not shared by its askeletal British homologue. In no instance, so far, would it appear that a brilliant green has been found associated with the Tealia. In the case of this particular Mushroom-coral it represents one of the dominant tints, as illustrated by the life-coloured imprint from the same photographic negative reproduced in Plate VI., Fig. 13, of the chromo-lithographic series. Rich olive greens and browns represent the additional more prevalent hues of this handsome species. These ground colours, including the brighter green, are usually variegated to the extent of the radiating septal lines, being indicated by conspicuous streaks of cream- or primrose-yellow, while the more or less inflated distal terminations of the tentacles are white or of a pale grey hue. It is noteworthy, in association with the illustration of the large specimen in its contracted state, that these light-coloured capitate extremities are retracted in such a manner that they present the aspect of sucking-disks or acetabulæ. The tentacles of this same species in their most attenuated condition are characteristically represented in the succeeding plate.

The figure that occupies the right-hand upper corner of the plate now under notice is of extreme interest. It represents a Mushroom-coral in that early stage of development in which it is attached to the corallum of some distinct species of coral, or other convenient fulcrum, by a distinct footstalk. After attaining to a size approximating to, or a little larger than, that of the specimen figured, it becomes detached from the stalk, and lies freely at the bottom of the water. In this manner the life history or ontogeny of the Fungia recapitulates, or, more correctly, foreshadows, the developmental history of the Feather-starfish, Antedon, in which more highly-specialised invertebrate type the organism begins its existence affixed to an elongated

stalk, from which it subsequently breaks free. This chapter in the life history of the Feather-star has justified the conjecture that its original progenitors were permanently stalked like some of the few existing Crinoids, and exceedingly numerous fossil Encrinites, or Stone-lilies. It may be analogously surmised as probable that the existing unattached Mushroom-corals are the specially-modified descendants of a pre-existing, permanently-stalked coral-stock. What form this simpler ancestral type was represented by cannot at present be accurately predicted ; but it is probable that, as in the case of the stalked Crinoidea, it attained to its maximum of development in the tranquil abysses of the ocean.

A point of interest has to be recorded in association with the reproductive phenomena of the Mushroom-coral. It has been discovered that the stalk, after the separation from it of the terminal tentaculiferous disk, is by no means dead. Portions of the somatic tissue and of the septal elements are left behind ; and these sprout anew, and produce, in course of time, similar discoidal coralla. The specimen figured in the accompanying plate indicates very distinctly, by the scar and ragged septal edges exposed to view a little beneath the expanded disk, the line of demarcation across which the preceding young corallum became separated. By virtue of their reproductive functions, the title of "Nurse-stocks" has been conferred upon these growth-forms of the genus Fungia. With reference to this plan of reproduction, the phenomena described undoubtedly correspond very nearly with those of the "Strobila" form of the Hydroid polyp, *Cyanea capillata* in which multiplication is similarly accomplished by repeated transverse segmentation and detachment. A somewhat abnormal example is figured in association with Plate VI. of the coloured series, in which two young Fungiæ are in course of development from the truncated end of a simple cylindrical Nurse-stock. All the examples of this Mushroom-coral figured in both the coloured and the accompanying photo-mezzotype plate were obtained from the fringing reefs of Adolphus Island at the entrance to Torres Strait, and were photographed in baths and other receptacles on board H.M.S. *Rambler*, then engaged in surveying the ground around the scene of the *Quetta* wreck, in which cruise, with the object of studying the fish and the coral fauna of the district, the author was privileged to travel as Captain Dawson's guest.

PLATE XXIV.

MUSHROOM-CORALS, ATTACHED, YOUNG, AND FULLY-EXPANDED STATES.

The lower of the two illustrations in this plate represents a group of the same species of Mushroom-coral, *Fungia crassitentaculata*, that occupies the entire area of the preceding plate. The individuals composing this group were originally collected at Adolphus Island in association with H.M.S. *Rambler's* cruise, and were thence transported to one of the pearl-shell cultivation pools of the Thursday Island reef. In this situation they soon made themselves

at home, and were subsequently photographed. Being there subjected to surroundings precisely identical with those under which they naturally exist, their tentacles, as will be observed, were extended in a more complete measure than obtains in the specimen examined under the artificial conditions previously described.

The upper illustration of Plate XXIV. depicts a species of the genus Fungia, apparently identical with *F. discus*, that is extremely abundant on the reefs in the neighbourhood of Port Denison. It differs from the preceding species in the finer serration of the septal edges and in the relatively small dimensions of the tentacles. The subject of the present illustration is of interest as representing by far the most prolific colony of "Nurse-stocks" of this or any other species of Fungia that has fallen within the author's observation. The supporting fulcrum is in this instance the dead corallum of an adult Mushroom-coral of the same species, having the lower third of its oral surface covered by an encrusting species of Montipora. Within the remaining superficial area are crowded together no fewer than thirteen stalked, immature, coralla of sizes varying from less than one quarter of an inch to one inch and a half in diameter. Ten of these are distinctly visible in the photographic reproduction, the remaining three being hidden beneath the expanded disks of the larger individuals. The extent to which they may be distorted by crowding is instructively illustrated by the misshapen contours of the impinging peripheries of the two contiguous pairs located near the centre of the selected fulcrum. It is a moot point whether this luxuriant colony of Nurse-stocks arose fortuitously from different sources, or in a single embryonic swarm from some more distant corallum, or whether they may not represent the product of the expiring vital energy of the defunct adult corallum to which they are united. This latter interpretation appears to be the most reasonable. It is worthy of note that in the majority of instances these attached juvenile coralla represent the first tentacular disk produced, the stalk being smooth and devoid of any scar. In a few cases, however, including the smallest cup-shaped corallum visible towards the upper left-hand side, the cicatrix demonstrating the separation from the stalk of a previously developed tentacular disk is as conspicuous from a lateral point of view as in the figure of a Nurse-stock of *Fungia crassitentaculata* included in the preceding plate. Numerous Nurse-stocks of this same species, *F. discus*, were collected in the Port Denison reefs, but, with few exceptions, as single individuals only, attached to the dead coralla of other Madreporaria or to a rock foundation. As the season of the year exercises a probable influence on the greater or less abundant development of Fungia Nurse-stocks, it may be recorded that the Port Denison examples were gathered in the month of August, 1889, that being one of the coldest months south of the equator. The Adolphus Island examples of *Fungia crassitentaculata* were collected early in June, 1890, and were obtained as late as September in the previous year on the fringing reef of Albany Island, which forms the eastern boundary of the picturesque Albany Pass, situated within a few miles of Adolphus Island.

PLATE XXV.

CORALS WITH EXPANDED POLYPS.

The figures included in this plate typify the living aspect ot three essentially distinct coral genera. The first portrays a small colony-stock of Goniopora, apparently identical with *G. lobata*, the living polyps of which, in this specimen, were scarcely distinguishable in form and colour from those of *Rhodaræa fruticosa*, illustrated by Plate VI., Fig. 4, of the chromo-lithograph series, the centres of the disks, or peristomes, and the tops of the tentacles being white, and the remaining surfaces a clear liver-brown. In common with other representative forms of the same genus, the polyps are capable of protrusion to a very considerable distance beyond the orifices of their corallites. In the photographic illustration given, these organs were only semi-extended. Other figures of the same coral, included in the coloured plate, will suffice to indicate the extensive range of colour variation that a single specific form may exhibit.

The second figure represents a small colony-stock of *Euphyllia rugosa* attached to a dead branchlet of a Madrepora. The polyps in this instance, also, are only partially extended; but they exhibit at many points their characteristic capitate contour. The fine granulated texture of their cylindrical shafts is distinct in silver prints from the original negative, and is discernible, with the aid of a hand-lens, in the mezzo reproduction. Illustrations of the colour variation to which this species is subject are abundantly given in Plate IV. of the chromotype series. The example photographically reproduced corresponded, among these, with the variety in which the shafts of all the tentacles were a delicate lilac, and their inflated extremities a pale apple-green. Both this and the Goniopora previously figured were obtained at Adolphus Island, Torres Strait, and photographed in extemporised aquaria on board H.M.S. *Rambler*.

The third or lowest figure in Plate XXV. depicts a mature corallum of *Pectinia Jardinei*, of which a young, fully-expanded colony-stock, coloured from life, is represented in Plate IV., Fig. 7, of the chromo series. It undoubtedly represents one of the most beautifully-tinted members of its class, constituting, when fully extended, a very attractive object. This coral has been collected by the author on the Warrior Island reef, and also in the vicinity of the Albany Pass, Torres Strait. Like the Euphylliæ, to which it is allied, it is apparently limited in its distribution to the equatorial zone. As shown in the coloured illustration, the corallum terminates inferiorly in a slender footstalk or pedicle, and is, in its earliest condition of development, attached to some supporting fulcrum. In all examples, however, collected by the author, including specimens less than half the size of the coloured one, the coralla were lying freely on the reef, and had evidently become detached at a very early period of their development. As thus collected in their natural condition, mostly just covered by the retreated

tide, the tentacles and peristomial membranes were often expanded to twice the length and dimensions exhibited in the figure. In the example photographically reproduced in Plate XXV., the polyps exhibit a condition of almost complete retraction, the tentacles amid such circumstances losing their otherwise characteristic capitate contour. The genus Pectinia, to which the coral is referred, has hitherto been associated only with a tropical American, Atlantic habitat. In one important feature it differs essentially from the members of the genus hitherto described. In all the Atlantic species the calicinal systems coalesce laterally, and so form one compact corallum, whereas, in the Torres Strait type, these systems, while forming, in adult coralla, elongate, variously-contorted series, are widely separated from one another. This structural feature is very clearly shown in the corallum of the example here photographed, now in the British Museum collection. In respect to its loosely convolute structural modification, this species differs from all previously-known Pectiniæ in the same manner as the representatives of the genus Mussa differ from Symphyllia; and it may eventually be found requisite, on this account, to institute a new generic, as well as specific, title for its distinction.

The specific title associated with this form has been conferred as a slight recognition of the hearty assistance and hospitality, on many occasions, extended to the author by Mr. Frank Jardine, of Somerset, Cape York, while engaged in investigating the fish and marine fauna of the Albany Pass.

PLATE XXVI.

ORGAN-PIPE CORAL WITH EXPANDED POLYPS.

The natural growth-conditions of this interesting species have been already illustrated and described in association with Plate XVIII., reference being made, in the same connection, to the coloured delineation of the expanded polyps contained in Chromo plate No. X. The example here figured was obtained at Thursday Island, and photographed from life while expanded in an extemporised aquarium. It is desirable to mention that the original photograph was taken on an ordinary whole-plate negative, $8\frac{1}{2}$ in. $\times$ $6\frac{1}{2}$ in., and represented the corallum and polyps in their precise natural size. In the accompanying photo-mezzotype reproduction, details are enlarged to the slight extent of increasing the area of the surface, by an inch and a half, in each direction. In other words, the polyps and the associated tubes may be regarded as being, approximately, one-sixth part as large again as their natural size.

PLATE XXVII.

AUTHOR'S METHODS OF PHOTOGRAPHING SUBMERGED CORALS, ETC.

There are many workers with the camera to whom, probably, the practical illustrations given in this plate of the methods employed by the author to obtain photographs of naturally submerged

corals, or of specimens under artificially induced conditions, will prove welcome. The necessary plan, in either instance, is to arrange for the disposition of the camera in a vertical position. This was accomplished by extemporising a square frame into which the camera fitted, an extra leg, in addition to those of the ordinary tripod, being supplied to support it. A more elaborately-finished apparatus could doubtless be made; but the results obtainable with the simple means employed sufficed for the author's purposes. A wide-angle lens is, of necessity, a *sine quâ non* for the photography of objects of the natural size at short distances. In the upper of the two figures given, the apparatus is represented as employed, on the foreshore area of one of the Thursday Island reefs, for the photography of a large sea-anemone *in situ* and under conditions precisely parallel to those under which the illustrations of the Stinging Anemone, Actinodendron, Plate XXII., and the fully expanded Mushroom-corals, Plate XXIV., were obtained. In the lower of the two figures, the same apparatus is represented as erected on the beach of one of the Barrier coral islets, an abundant supply of suitable subjects for its employment having been collected together in the extemporised aquaria of various shapes and sizes, distributed around. The actual scene of this illustration is Rocky Island, about lat. $14\frac{1}{2}°$ S., within sight of the islands known as the Lizard and North and South Directions; it constitutes a favourite station for the prosecution of the Bêche-de-mer fishing industry. The grass hut partly visible in the background represents the description of tenement commonly constructed for the accommodation of the "boss" or foreman of the fishing and curing operations, and is also the one which the author occupied, as very comfortable headquarters, during two weeks spent in investigating and reporting upon the Bêche-de-mer fisheries of this district.

Some estimate of the varieties of Trepang or Bêche-de-mer obtainable on the neighbouring reefs is afforded by the contents of the large bath in the foreground, which include over half-a-dozen of the most valuable Barrier Reef specific types. Among the occupants of the adjacent receptacles, waiting to "sit" for their portraits, the circular basin invites attention through being fairly filled up with a small specimen of the Giant Anemone *Discosoma Haddoni*, which is represented separately in Plate XXI. Before quitting the subject of the author's vertical photographic method, it seems almost superfluous to add that the focussing-cloth, while indispensable in actual practice, has been omitted in each illustration, with the express object of giving a clear view of the apparatus and its mode of utilisation. The method is in itself so simple of application that the hope is entertained that it will be adopted by many voyagers in tropical seas, who would thus be provided with golden opportunities of enriching science with a knowledge of the life-aspects of rare and interesting marine organisms that, even where artistic talent is available, it is almost impossible to render faithfully with brush and pencil.

PLATE XXVIII.

SUBMERGED SEA-URCHINS, PALM ISLANDS REEF.

This plate, by way of comparison with the preceding ones, subserves the purpose of illustrating the very varied nature of the fauna that inhabit distinct reefs, or even separate areas of the same reef. The prominent form in this instance is the long, slender-spined Sea-urchin, *Diadema setosa*, which abounds, in social clusters, just beneath the surface at low ebb-tide, over large areas of the Palm Islands fringing reef. In addition to the conspicuous groups occupying the central foreground, many scattered individuals may be detected, with the assistance of a hand-glass, ensconced among the more remote dead and living coral boulders. A wade through a reef, thickly tenanted with these organisms, necessitates treading circumspectly ; and it is almost impossible in the course of an enthusiastic search for novelties among the coral-stocks to escape scatheless. Their spines are slender, eight or ten inches long, and sharper than needles. Their owners, apparently, possess an instinctive faculty for concentrating their serried ranks, and so present an impregnable *chevaux-de-frise* towards the approaching foe. Nevertheless, and notwithstanding accumulated experiences, these magnificent Echini always seemed to exert a fascinating influence, compelling the writer to make the attempt to pick one up with unprotected hands. Invariably, however, and though the creature was approached with the greatest precaution, the spines pierced one's fingers at, seemingly, some distance before they were visibly reached. It was a common notion among the Bêche-de-mer fishers that the animals could elastically, or telescopically, extend their spines to meet the intruding hand. The true interpretation of the phenomenon is, probably, to be found in the fact that the distal ends of the spines are of such extreme tenuity, that they are imperceptible through the surface of the water. In some instances, doubtless, a lack of knowledge of the common law of water refraction is accountable, in the case of an inexperienced experimenter, for the uncomtemplated precursory impalement and accompanying expostulations. The points of the spines of this Sea-urchin, though so easily embedded in the flesh, are very difficult to extract. Left alone, they in a week or two apparently disappear, and the author was of the opinion that, being almost pure carbonate of lime, they probably dissolved in the blood. Professor A. C. Haddon has, however, informed him that the spine points, like incepted needles, have, in his own experience, after a year's interval, worked their way out at remote distances from where they entered. The capacity for lime absorption probably varies in the blood of different individuals.

A coloured representation of one of these long-spined Diademæ is included in Plate XI. of the chromo-lithographic series. It serves to illustrate a feature conspicuous in the submerged living organism that does not appear to have been commonly observed. Reference is here made to the spheroidal structure located among the spines on the upper surface of the test. This

W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

FRINGING REEF, PORT DENISON, WITH MILLEPORA ALCICORNIS.

structure, on near examination, is found to be a pedunculated, bladder-like membrane connected with the vent, and communicating by a circular aperture with the exterior. On raising the Sea-urchin above the surface of the water, the structure is immediately withdrawn into the cavity of the body. It not improbably fulfils a respiratory function. Other structural points attract notice in the living organism. Disposed at equal distances around the aboral aperture, with its bulbous appendage, are five ovate pigment masses of a brilliant ultramarine-blue. These structures, in accordance with the results of the most recent research, would appear to possess all the essential elements of complex visual organs. In an allied, shorter-spined form, *Astropyga Freudenbergi*, obtained off the coast of Ceylon, recently described and illustrated in a magnificent monograph by the cousins Dr. P. and Dr. F. Sarasin, similar brilliant blue visual spots are developed in radiating lines throughout the surface of the shell or test, rendering the organism exceptionally beautiful Outside the blue eye-spots in Diadema, five somewhat large, irregularly ovate, pure white patches are usually visible. These are the discharged products of the reproductive organs, and are commonly composed of a tenacious, exuding mass of ova.

The living corals conspicuous in this reef-view are few and far between. They embrace for the most part Brain-corals, Cœloriæ and Goniastrææ. Dead coralla, more or less encrusted with Alcyonarian polyparies, occupy the most extensive area; and many of these, where the Alcyonaria are absent, give support to colonies of the Frilled Clam, *Tridacna compressa*, previously referred to as a characteristic denizen of the Palm Islands reefs.

A species of starfish that is abundant in the Palm Islands reefs, and also throughout the Great Barrier district, is represented by Plate XI., Fig. 8, of the chromo-lithographic series. Its technical name is *Linckia lævigata* but it differs conspicuously from its European congeners in its unusual and exceedingly attractive colours. The entire body is dappled over with graduating shades of the purest Antwerp blue, while the long tubular locomotor suckers or pedicels are bright chrome-yellow. Two other members of the same echinodermatous, or sea-urchin and starfish, class, observed on the Palm Islands reefs, are depicted in the same coloured plate. These are the two Feather-starfish, *Antedon* sp., represented by Figs. 7 and 7A, clinging to the corallum of the Gorgonia in the right-hand upper corner. In general form they resemble the English Feather-star, *Comatula rosacea;* but they possess about forty, in place of the ten, pinnate arms of the European type. The variety of hues exhibited by this Barrier Reef species are legion, running through every gradation of tint from pale yellow to rose-pink, deep crimson and black, and including every conceivable intermixture of those colours. One especially handsome racial variety of this Feather-star, obtained at Thursday Island, had its fern-like arms resplendent with shades of old-gold and bronze-green. The special biological interest attached to this Feather-star group of starfishes is that they begin life attached to submarine objects by a slender stalk. They subsequently become detached, and thenceforward lead a free-roving

existence. In this respect their earliest or larval condition corresponds with the adult state of the permanently stalked and sedentary Crinoids or Sea-lilies, most abundant in earlier geological epochs, but now represented by but a few comparatively rare abyssal forms. From an evolutionary point of view, the roving Feather-stars are consequently regarded as the direct descendants of the permanently stalked Lily-stars, with which, in all other essential anatomical features, they are found to correspond.

PLATE XXIX.

(A.)—OUTER BARRIER REEF, WITH GIANT CLAMS AND BÊCHE-DE-MER.

This reef-scape is highly typical of those vast areas of the Outer Barrier district from which the richest harvests of Trepang or Bêche-de-mer are systematically obtained. Examples of the Bêche-de-mer, outstretched at ease, may be discerned beneath the surface of the shallow, glass-clear water that, at the lowest tide-ebb, still covers the most considerable area of the reef-surface. The most conspicuous object in this illustration is undoubtedly, however, the huge mass in the immediate foreground, which, excepting for its sinuous upper edge, might be readily mistaken for an eroded coral-boulder. This represents, on its native reef, that most colossal of living bivalve molluscs, the Giant Clam, *Tridacna gigas*. The specimen here figured measured just three feet six inches in length, but it by no means illustrates the largest dimensions that may obtain. A measurement of as much as four feet, with an associated weight, with the enclosed living animal, of at least six or seven hundredweight, frequently occurs. The largest pair of shells of this species displayed at the International Fisheries Exhibition, London, 1883, were obtained from Singapore. They weighed 3cwt. 3qrs. 14lbs., and measured three feet four inches in length. This record could, undoubtedly, have been easily beaten from the Queensland Barrier, had the necessary time and money been expended in searching for, and transporting, the bulkiest specimens. Rumours are indeed rife along the Barrier district, and more especially within striking distance of Cooktown, of huge monsters over ten feet long, and weighing at least a ton. Such specimens inhabit deeper water, and the labour and appliances necessary to raise them from their rocky bed are not forthcoming without special inducements. The prodigious dimensions of as much even as fourteen feet were reported on one occasion to Captain G. P. Heath, R.N., Portmaster of Queensland, from the reefs off Cooktown. The freely-offered use of such boats and gear as might be required for transporting this monster of the deep from its coral fastness did not, it is to be regretted, result in its successful capture. The great Barrier Sea-serpent, run to earth in a succeeding chapter, was at this critical time, it may be mentioned, awaiting discovery.

A fallacy very widely prevails concerning the growth-conditions of the Giant Clam. It is commonly stated, in popular works on natural history, that the animal is firmly attached to the

coral rock by a byssus, of such size and strength that the aid of an axe is required to release it from its moorings. As a matter of fact, these Clams, in their adult condition, possess neither byssus nor other anchoring ligament, but lie entirely free on the surface of the reef. Similar growth-conditions obtain also in the case of the smaller spotted or Bear's-foot Clam, *Hippopus maculatus*, that abounds on the same reefs; it being only the more ornate Frilled, or Furbelow, Clam, *Tridacna compressa*, that is permanently attached. The anchoring cable in this species, moreover, is not a bundle of thread-like filaments, or "byssus," of the more familiar type, but rather a solid fleshy, cartilaginoid plug. The colours of the mantle membranes, conspicuously visible between the slightly gaping valves, in the living animal of the Giant Clam, are by no means brilliant, like those of the last-named species, being almost invariably light-brown, with transverse streaks of a darker hue of the same tint. From the references made to this species, *Tridacna gigas*, in many natural-history works, and accounts of voyages of discovery, including Jukes' "Voyage of H.M.S. Fly," Vol. I., p. 6, it is very evident that the permanently attached and most commonly coral-embedded *Tridacna compressa* has been mistaken for the young of its gigantic relative. Under the title of "Gigantic Cockles," these Barrier Reef Clams were first recorded by Captain Cook ("First Voyage Round the World," Vol. II., 1821), who attests to their excellent edible properties. Where, however, so many other shell-fish abound, of more tender and delicate substance and flavour, these colossal bivalves are, except by the natives, held in very little account. A considerable trade is, at the same time, carried on with the ordinary large-sized shells, which are obtained chiefly by the Bêche-de-mer fishers, and retailed for decorative purposes at an average rate of £1 a pair.

A brief examination of the reef-scape now under discussion will reveal the presence of two other large Tridacnæ, a little more towards the background, on the same side of the picture. This suffices, to some extent, to indicate their gregarious habits. These more remote specimens have much younger, smoother, shells than the foreground example, and exhibit very distinctly their typical fluted contour. In the case of the older shells, it not unfrequently happens that they are so thickly encrusted with corals, sponges, and other marine growths, that their real identity is almost completely disguised. It is under such conditions that they undoubtedly constitute a formidable source of danger to those whose calling necessitates spending the greater portion of their days in collecting the highly valuable commercial products of the reefs, by wading or diving. A foot inadvertently inserted betwixt the gaping valves of a large Tridacna is held with a grip as firm and unyielding as that of the strongest steel man-trap, and, unless the assistance of a comrade, with a stout knife, or axe, or crowbar, is at hand, the victim stands little or no chance of escaping a watery grave. Should such misadventure befall the fisherman when wading, death approaches slowly with the rising of the tide; his fate in this case being a less enviable one than if trapped by the bivalve when diving, under which circumstances drowning ensues speedily. Several instances of loss of life among the native Bêche-de-

mer fishers on the Queensland Barrier, through the direct agency of these colossal shell-fish, have been reported to the author.

(B.)—OUTER BARRIER REEF WITH EMPTY SHELL OF GIANT CLAM.

This plate, which might have been appropriately labelled "House to Let, with Immediate Possession," represents, as its central object of attraction, the gleaming, white internal surface of a recently defunct Tridacna. Actually, it is a specimen with the body removed preparatory to transportation; the almost snowy whiteness of the porcelain-like lining of the ponderous shells forms a striking and picturesque contrast against the somewhat dim, fast-fading light that illumines the surrounding reef-scape. On the distant horizon a wooded coral islet, the fac-simile of hundreds scattered throughout the Great Barrier region, is upreared against the sky. The tide, rapidly rising, has left but few coral heads uncovered; the most notable among these are the bouquet-shaped coralla of *Madrepora millepora*, resplendent in life with contrasting tints of cream and mauve, and the more robust terminal branchlets of the brilliant green variety of the Stags'-horn coral, *Madrepora hebes*. In the most immediate foreground is a well-defined patch of a golden-brown Alcyonarian, referable to the genus Spongodes.

PLATE XXX.

(A.)—FLOTSAM, WRECK OF MISSION SCHOONER "HARRIER."

"Flotsam and Jetsam," the collective title of this plate, is suggestively represented in the former association (Fig. A) by the stranded hulk of the schooner *Harrier*, formerly belonging to Her Majesty's Navy, but within recent years made over to the New Guinea Mission Service. While making one of her customary passages from Port Moresby to Cooktown, and after having safely threaded the Lark Pass and other intricacies of the Outer Barrier, she ran hopelessly aground on what is known as F reef, some twenty miles only from her port of destination. Fortunately, no lives were lost on this occasion. The author was associated with the honour of discovering and rescuing the captain and crew from their perilous position, while returning in the Queensland Government schooner *Governor Cairns* from an excursion to the Barrier fishing-stations.

It would be a matter of congratulation if similar immunity from loss of life could be recorded of every wreck recently associated with the Great Barrier region. One most noteworthy and painful instance, only too fresh in the mind of every Queenslander, was the loss of the good ship *Quetta* at the entrance to Torres Strait on the night of February 28, 1890. This magnificent

steamer had a gross register of 3,480 tons, and was one of the finest vessels of the British India and Australian Steam Navigation Company's fleet, built for the special object of carrying Her Majesty's mails between Queensland Ports and London. After having safely navigated all the dangers and intricacies of the Barrier Inner-channel, north of Break-sea Spit, and while under full steam along the charted course between Albany and Adolphus Islands, an unknown rock was suddenly struck, and, within so short a space of time as three minutes, the vessel was at the bottom of the sea in a depth of thirteen fathoms. Of the 282 souls, all told, on board, as many as 120 perished, while the escape of the 162 survivors was, in certain instances, almost miraculous. Notable among these, were the cases of two young lady passengers, one of whom a Miss Lacy, aged sixteen, swam and floated on the surface of the water for no less a period than thirty-five hours before being discovered and picked up by one of the rescue boats. The other, a Miss Nicklin, after swimming and drifting on a plank for an almost equal period, gained the shore of Adolphus Island, whence she was rescued by the Q.G.S. *Albatross*, which was despatched to the scene of the wreck from Thursday Island, immediately on receipt of intelligence of the catastrophe.

The cargo on board the *Quetta* when she sank included 2,278 bales of wool, 4,260 cases of meat, 60 tons of silver ore, and 260 tons of tallow. By combined diving and blasting operations, a small percentage of this cargo was recovered, though with great difficulty, by reason of the abnormally strong tidal currents. The bulk of it, however, remains at the bottom of the sea, and, in consequence of the costliness of salvage operations, is scarcely likely now to be recovered. The preliminary investigations made by the divers, and confirmed by the subsequent surveys of H.M.S. *Rambler* and Q.G.S. *Paluma*, revealed the fact that the rock upon which the vessel struck—tearing her side open for nearly two-thirds of her total length—was a pinnacle of growing coral. This fact is of very considerable importance, since it tends to demonstrate that coral grows at a much more rapid rate than is generally supposed, and indicates the desirability of making new surveys of vessel-tracks through coral-growing areas at intervals of at least every few decades. The local charts in use up to the date of the *Quetta* wreck were compiled chiefly from the Admiralty surveys made by Captains Flinders, Blackwood, Stanley, Yule, and Denham, R.N., within dates varying from 1802 to 1860. It is, in the author's opinion, highly probable that the coral pinnacle upon which the *Quetta* struck with such fatal force grew up to within striking distance of deep-draught vessels subsequently to the survey made thirty or forty years before. In this association, the investigations initiated at Thursday Island, with the direct object of ascertaining the growth rate of specific varieties of coral, referred to at length in connection with the "Charted Reef," Plate II., possess, as will be recognised, an important bearing. In order, however, to arrive at an absolutely correct standard for comparison, it will be necessary to take measurements of permanently submerged coral-masses growing amid conditions identical with those that surround the *Quetta* rock. This could be accomplished at a

very moderate expenditure, with the co-operation of the diving community at Thursday Island, and would undoubtedly constitute a legitimate and exceedingly important auxiliary subject for investigation in association with the Admiralty survey.

The title of "Flotsam and Jetsam," introduced with the opening paragraph of the plate description, invites reference to one other somewhat analogous, but much earlier, event. In this instance, all painful associations of loss of life are, happily, absent, the narrative resolving itself into an almost romantic record of discovered treasure-trove. The good fortune of its discovery on this occasion fell to the lot of Mr. Frank Jardine, the genial owner of the cattle ranche and fishing station at Somerset, in the Albany Pass, to whose ready aid and unlimited hospitality, extended to them in their day of sore distress, the survivors from the *Quetta* accident owe their life-long gratitude. In the minds of many, doubtless, there will seem to be an almost providentially directed connection betwixt those good deeds and this later episode. It so happened that one of Mr. Jardine's boats, prospecting in pastures new for a remunerative fishing ground, was driven, through stress of weather, to take shelter in one of those naturally-protected coves that abound among the Barrier reefs. Lying to in the selected haven, the flukes of a time-worn anchor were discerned at a short distance from the boat at low ebb-tide. Acting on the idea that the instrument might in some way prove useful, steps were taken to remove it. The surprise and gratification experienced on a mass of coin being laid bare on the immediate resting-ground of the eroded anchor, can be well imagined. Further investigation led to the discovery of a larger mass of coin than could be transported by the fishing lugger in a single voyage, several trips from Somerset being eventually undertaken before the little mine was exhausted.

The specie exhumed proved on examination to be Spanish, chiefly silver, dollars, bearing various dates within the first two decades of the current century. Mingled among these were discovered a fair sprinkling of golden coins of the same epoch. The state of preservation of the dollars recovered was remarkable. The greater portion of them were, as it were, soldered together by their flat surfaces in roulette form, after the manner of the familiar gelatine lozenges when allowed to get damp. Solid silver masses of many pounds weight were thus in many instances produced, from which, however, the more superficial coins could in most instances be cleanly detached with a deft tap of chisel and hammer. The aggregate value of the treasure thus recovered represented, as may be anticipated, a sum total of several thousand pounds.

So far as it is possible to determine, the vessel originally carrying this coin was of Spanish nationality, and either laden with specie for the payment of the civil and military staffs of the Spanish colony of Manilla or equipped for trading among the spice-bearing islands of the Malay Archipelago, and in either case driven out of its course probably by the north-west monsoon, and wrecked on the scene of the anchor-and-coin discovery. Among the very few other objects disinterred at the same spot, mention may be made of a number of fragments

"DOG" REEF, SADDLE-BACK ISLAND, PORT DENISON.

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

MILLEPORA AND ALCYONARIA FRINGING REEF, PORT DENISON.

of coloured glass, which, it is anticipated, formed part of the captain's or officers' mess equipment.

Doubtless many another treasure lies hidden, and will probably never be recovered from among the coral mazes of the Great Barrier Reef. There is one sunken treasure, however, of classic interest to all Australians, of which knowledge is certain, though the exact *locale* cannot be fixed, that has again and again been the object of strenuous exertion to recover. These are Captain Cook's guns, six in number, cast overboard from his exploring ship, the *Endeavour*, when temporarily aground on a reef within sight of Cape Tribulation, a little to the south of Cooktown, in the course of that earliest scientific survey of the Queensland and East Australian coast. The position given by Captain Cook in the original description of his travels (Vol. II., p. 135, 1821) as the scene of the disaster which so nearly wrecked his vessel, is lat. 15° 45′ S., and between six and seven leagues from the mainland. The ground in the vicinity has been searched with the aid of divers, though so far without result, and it is of course by no means improbable that the guns have long since been buried beneath an impenetrable mass of growing coral.

(B.)—JETSAM, STORM-STRANDED CORAL-ROCKS.

"Jetsam," the title most appropriately associated with the lower of the illustrations of Plate XXX., is represented by a reef-scene in the Capricorn Islands group, depicting huge masses of the consolidated coral-rock torn off its outer edge and hurled far up on the face of the level platform reef. Phenomena of this description are abundantly illustrated throughout the length and breadth of the Barrier, and are mostly associated with the cyclonic storms that, during the prevalence of the north-west monsoon, occasionally sweep the reefs with irresistible force, though, fortunately, over limited areas. The larger rock-masses stranded on this reef-view are, respectively, over a ton in weight, and consist exclusively of a conglomerate of coral fragments varying from minutely comminuted particles, which constitute the main bulk of the mass, to almost entire, though much eroded, coralla, inches or feet in diameter. The much-weathered, uneven surfaces of these stranded coral-rocks offer a secure, permanent anchorage, or a temporary lodgment to a considerable host of molluscan and other littoral organisms. Barnacles, multivalve Chitons, and the coral-rock oyster, *Ostrea mordax*, are distributed more particularly over the upper surfaces of these rock-masses, while their ground storey, or excavated under-surface, usually shelters a number of Holothuridæ or Bêche-de-mer, *Holothuria atra* and *H. coluber*, which, during the rising of the tide, extend themselves on all sides in search of food.

The rock-masses in this reef-view are entirely covered at high water. It frequently happens, however, more especially on the outer or weather edge of the reef, that the detached storm-stranded blocks are of such dimensions that their crowns are elevated several feet above high-water mark. Under these conditions their upper surfaces become perfectly

black and weathered; and, standing up in bold colour, are in contrast with the snow-white line of breakers. They are popularly known as "nigger heads." Jukes, in his "Voyage of the Fly,' attests to examples of analogous blocks resting on the Barrier margin, twelve miles south-west of Raine's Islet. They are situated about two hundred yards from the outer edge of the reef, and measure, in some instances, no less than from twenty to twenty-five feet long and ten or twelve feet high; their summits are, in some cases, elevated as much as eight feet above high-water. The general surface of these rocks is very rugged and honeycombed, and passes upwards in sharp points and crags, and it was only in the sheltered hollows one could detect that they were composed almost entirely of a species of Porites, with the cells for the most part directed upwards in apparently their natural position of growth. Commenting on these huge dimensions, Mr. Jukes was doubtful whether or not to regard the blocks as remnants of a much larger mass that had been gradually eaten away and eroded by the action of sea and weather, and as furnishing evidence of elevation in this region. The fact that these huge blocks seemingly passed down into the main body of the reef lent support to this suggestion. This embedment in, or solid union with, the main body of the roof is, however, characteristic of all similar stranded masses of any antiquity, and is of itself corroborative evidence of the augmentation of the reef conglomerate that is constantly, though slowly, progressing within intra-tidal areas. To go further, it will be hereafter shown that the deep embedment of those cast-up rock-masses in the substance of the reef is direct evidence of subsidence rather than of elevation.

Mr. Jukes' doubts as to the possibility of the masses he described being lifted to their position on the reef by any conceivable storm may be set aside in face of the ocular evidence, in both this and the succeeding plate, of what can be effected by storm-waves in confined channels and relatively shallow water. On the outer face of the Barrier, with the whole mass of the fathomless Pacific to draw upon, the hydraulic lifting power of the gigantic storm-begotten rollers, while practically incalculable, is sufficient to account for the transport of the rock-masses above described.

PLATE XXXI.

HURRICANE-STRANDED CORAL-MASSES, PORT DENISON.

A still more graphic exposition of the *rôle* enacted by cataclysmic influences in the making and unmaking of coral-reefs, and the associated products, is furnished by the accompanying plate. It represents the north-west shore of Saddleback Island, Port Denison, which has already furnished the subjects of several illustrations. The coral-masses piled up here in inextricable confusion represent the complete wreckage, by a hurricane, of the fringing reef that skirted this side of the island. The massive Astræaceæ, Meandrinæ, and Symphyllias have been

torn up and rolled together like small pebbles on an ordinary beach, until the superficial characters of their corallites are in many instances well-nigh obliterated and their normal irregular contours are ground into sub-spherical symmetry. The fate of the branching Madreporæ, which must have entered largely into the composition of this reef, is suggestively illustrated by the mass of finely triturated material *en evidence* in the central foreground. This scene of chaos represents the effect of a hurricane of only a few hours' duration. The parallel of such a storm is fortunately unknown in British latitudes at the present day. It is an open question, however, whether similar meteorological conditions did not prevail in that earlier Tertiary period when crocodiles and hippopotami consorted in the Valley of the Thames, or in the more remote European reef-coral-producing days of the Oolitic epoch. On our own south-coast shores, the boulder-heaped expanse of the Chessel beach bears a remarkable general resemblance to the Saddleback Island view, and was, not improbably, primarily fashioned under corresponding cataclysmic conditions.

It is fortunately possible to fix the precise date of the Saddleback Island storm, it being coincident with a cyclone of exceptional severity that swept through the vicinity of Bowen. A graphic account of it, which appeared at the time in a local paper, is herewith reproduced. It amply accounts for the chaotic coral scene portrayed.—

A REPORT ON THE CYCLONE AT BOWEN, 30TH JANUARY, 1884.

By Mr. Christison, Manager of the Poole Island Meat Freezing Works.

At eight o'clock p.m. on Tuesday evening, the 29th of January, 1884, I went my usual rounds over the premises. The refrigerating machinery had been working satisfactorily for some days; four chambers in the freezing house were full of quarters of beef, containing in all about 200 carcasses. The temperature of the rooms showed 20° above zero. Two of the rooms contained quarters of frozen beef bagged ready to ship on board the *Fiado* at daybreak on the following (Wednesday) morning. The success of this company seemed to be at last assured. At ten o'clock p.m. an ominous silence augured a change from the northerly weather which had prevailed for some time past. This silence had lasted but a short time when a strong wind rose from a point S. 25° W., increasing in velocity and pursuing a complete circle. When it reached S. 45° E., about one a.m. on Wednesday, it blew with terrific violence, the sea rising fully ten feet higher than any drift-marks previously seen upon the island. Two miles out to sea, forming two-thirds of a circle, there appeared a continuous phosphorescent light, very brilliant, with a background of impenetrable darkness. A dashing rain was falling with a force of wind so powerful that it was impossible to stand without a fast hold of something stationary. The night passed, and as day broke the tempest increased, the wind, meanwhile, having veered round to N. 20° W., leaving but a small space to complete the circle. Man was powerless to attempt anything, the convulsed elements warring against each other with maddening din. The cyclone was at its height from daylight until noon. The steam launch, punts, and boats were driven from their moorings, and disappeared. The jetty, after a gallant tussle with the wind and sea, next gave way, its massive timbers being broken into fragments and driven on to the pumping machinery, constructed to supply the works with 30,000 gallons of sea water per hour. By noon the wreck was complete, and although the damage done has not yet been fully ascertained, it cannot fall short of £12,000. Only to an eye-witness could the full force of this cyclone be realised. Some

conception of it may, however, be gained from the fact that rocks of tons' weight disappeared from their beds, and stones, fully 100lb. in weight, were thrown in masses fully 30 feet high. Volumes of water rose 50 feet high, which the wind separated into spray and then disappeared as mist. Even the sea-birds were killed, and trees, apparently of fifty years' growth, were snapped like carrots. The sea appeared to know no bounds, and had it risen about 15 feet higher, the entire island would have been submerged. The occurrence at Java being still fresh in our memories we feared that this culminating catastrophe was about to happen. Had it done so, none would have been left to tell this tale. The sea has now gone back and the sun re-appeared, leaving the island strewn with wreckage.

It is worthy of note, in association with the present plate, that a high bank of coral boulders is thrown up among the vegetation, in the extreme background, to a considerable height above the reach of the highest spring-tides, of which the vegetation marks the normal limit. This phenomenon fully substantiates the record concerning the abnormal ingress of the sea embodied in the foregoing account of the same disastrous cyclone.

PLATE XXXII.

SPECIMENS OF CORAL ROCK CONGLOMERATES.

The special purpose of this plate is to illustrate the structural composition of the bulk of the material of which coral-reefs are composed. The multiform and multi-coloured coral-growths, whose life aspects have been variously portrayed in a large number of the preceding plates, represent a thin superficial crust that overlies a relatively small and chequered surface of the entire reef-mass. The solid basis upon which these corals grow, and the vast expanses of solid coral rock that are accumulated at a considerably higher plane than that wherein the coral polyps can exist, is built up almost exclusively of the finely triturated detritus of the skeletons of preceding polyp generations, combined with that of the calcareous shells of molluscs and other lime-secreting organisms. The local tides and currents are a main factor in determining the ultimate composition of this coral rock, sweeping the finer or coarser constituents into defined areas when they become solidified in forms varying in aspect and texture from that of the finest grained limestone and oolite to the coarsest conglomerate. The larger rock fragment illustrated by Fig. 5 of the accompanying plate furnishes a very typical example of the character of the main mass of the ordinary inshore or platform reefs that skirt the shore of every coral islet or mainland-fringing reef, or that, again, composes the most elevated stratum of the innumerable isolated reefs of the Barrier system that are awash at ordinary low tides. The specimen above referred to was separated from one of the storm-detached masses of the platform reef at Rocky Island. Its composition, as may be recognised on examination with a hand-glass, consists mostly of minutely triturated coral and shell fragments less than one-eighth of an inch in diameter, eroded, and subsequently so encrusted with molecular calcareous deposits that their individual

identity is indeterminable. Here and there, however, may be recognised the discoidal tests of the Foraminifer, *Orbitolites;* and, on the opposite side to that illustrated, a fragment of the corallum of a Goniastræa, nearly an inch in diameter, is conspicuously embedded.

The fine molecular or granular calcareous deposit that encrusts the coarser constituent particles of the platform-rock specimens above referred to represents a very important element in the function of reef-rock construction. It is, in point of fact, the paste-like cement that binds all these independent elements into one consolidated mass, previously held in solution in the sea-water, and precipitated by its evaporation on the retreat of the tide. This cementing action of the sea-water in coral seas, through its saturation with carbonate of lime, is particularly well illustrated on the foreshore of Thursday Island, immediately below ordinary high-water mark ; this area, after submersion and complete infiltration with salt water, is then left for a long interval to the active evaporating agency of the tropical sun. Not only are shell and coral fragments bound together by the lime cement, but even granite pebbles of considerable size are found, on attempting to pick them up separately, to be firmly coherent. In a similar manner, washed-up shells, apparently freshly-deposited and lying loosely on the surface of the platform rock, prove to be firmly attached to it by an almost invisibly thin film of lime cement.

The upper figures, Nos. 1 to 4 of Plate XXXII., illustrate this binding property of the repeatedly evaporated, lime-impregnated sea-water in a highly instructive manner. These specimens were collected by the author on the foreshore of Sweer's Island in the Gulf of Carpentaria. Nos. 3 and 4 represent a loosely coherent breccia formed of small, almost perfect shells and larger shell-pieces, mingled with fragments of various species of coral, in which the coralla of the several genera Madrepora, Turbinaria, and Porites may be distinctly recognised. Scattered among these, there is finally a considerable intersprinkling of ironstone gravel. In neither of these two specimens is there any admixture or infiltration of finer grit or sand, the entire constituent fragments being loosely adherent, and falling readily asunder if roughly handled. In Nos. 1 and 2 from the same beach there is a substantial basis of red feruginous siliceous sand, so consolidated as to form a compact sandstone, among which shells and ironstone gravel, without any admixture of coral, are irregularly scattered.

This inter-tidal area throughout the lime-saturated, tropical, coral seas undoubtedly represents one of the most active and visibly effective of Nature's petrological laboratories. Loosely-aggregated breccia, conglomerate, or limestone of such fine and solid texture that it rings with the hammer, with every intermediate variety, are here in visible course of manufacture with a celerity unparalleled under any other conditions. How far the study of this active rock-forming phenomenon may or may not aid in a final settlement between the conflicting beliefs in subsidence and elevation under which the Great Barrier Reef of Australia is thought to have been originally constructed is a matter which will receive some attention in the following chapter.

Had space permitted, another highly interesting and instructive photograph would have

been reproduced here, viz., a view of the low sand cliff immediately facing the beach on Sweer's Island, where the specimens just described were collected. As since ascertained, it was the subject of observation by Captain King, and is referred to in Vol. II. of his "Surveying Voyage to Australia." The composition of the cliff is described by Captain King as "a stalactite concretion of quartzose, sand, and fine gravel, cemented by reddish carbonate of lime." The aspect of this cliff is very singular, its exposed face being, as it were, evenly fluted, and composed of closely-aggregated sand tubuli, which are continued perpendicularly through the substance of the cliff, such structure giving detached portions of the mass, when viewed vertically, a coarsely-honeycombed appearance. Some twenty years ago Sweer's Island was visited by a devastating hurricane, which well nigh wrecked the homestead established there, and during it this cliff, ranging from ten to twenty feet in height, was more or less completely submerged. Similar invasions of the sea have, no doubt, occurred at irregular intervals throughout many centuries. These cataclysmic inundations, supplemented by the showers of spray thrown abundantly on the face and shore borders of the cliff by ordinary storms, amply account, taking into consideration the lime-saturated and cementing properties of the sea-water, here attested to, for this remarkable aggregation of lime and silica. The action of the latest hurricane, and accompanying inundation, it may be here mentioned, was to undermine an extensive area of the face of the cliff, to such an extent, that a large portion has fallen down and lies scattered in huge, heaped-up blocks at high-tide level. A little way inland, out of the reach of the sea and spray, the stratum of siliceous sand and ironstone gravel occurs without any admixture of carbonate of lime.

PLATE XXXIII.

(A.)—OUTER BARRIER REEF, WITH SUBMERGED BÊCHE-DE-MER.

This reef-scene is taken from an area closely abutting upon the one (Plate XXIX.) illustrating the natural habitat of the Giant Clam-shell, *Tridacna gigas.* The specimens of Bêche-de-mer, dimly visible through the water in the foreground, towards the left, are what are known as "ordinary Red-fish," *Actinopyga obesa,* one of the most valuable commercial species. The several small fishing vessels discernible on the distant horizon represent the description of shallow-draught craft most commonly employed in this fishery, and manned with native crews, by whom a clean sweep will presently be made of the many thousands of Bêche-de-mer, similar to those in the foreground, scattered over the vast surface of the reef. There is a conspicuous coral-growth in this reef-view that does not enter into the composition of the preceding plates. This is represented by the obtusely-lobed, or clavate, masses nearest to the front on the left-hand side, and by an isolated corallum in the lower right-hand corner. This species, *Alveopora retusa,* is remarkable for the extremely porous, almost lace-like, delicacy of its superficial corallites.

The polyps which secrete it closely resemble those represented in Chromo plate No. VIII., Fig. 3, being delicate apple-green in hue, and protrusible to long distances beyond their coral basis. A little to the rear of the larger colony-stock of this species are several corymbiform coralla of the brilliant lilac *Madrepora gemmifera.*

(B.)—LADY ELLIOT ISLAND REEF, WITH EXTENDED BÊCHE-DE-MER.

Lady Elliot Island reef, delineated in this plate, is interesting, in addition to the associated Bêche-de-mer, on account of its belonging to the most southern coral islet of the Great Barrier system. It lies in lat. 24° 5″ S., a little south of Bustard Head, is elevated some eight or ten feet only above high-tide line, and is the site of a substantial lighthouse. The corals entering into the composition of the reef include a number of species identical with those recorded in association with the Port Denison reefs; *Madrepora millepora, Pocillopora damicornis, Lophoseris cristata,* and a species of *Cœloria* being most conspicuously visible. Long-spined Diademæ and Frilled Clams, *Tridacna compressa,* referred to in association with the Palm Islands reefs, were abundant on this reef.

The attenuate, fully-extended Bêche-de-mer in the foreground of this picture represents one of the commonest Barrier Reef species, *Holothuria atra.* It is, unfortunately, of little commercial use, shrinking up to an almost hollow skin when boiled and smoked in the ordinary manner; but it is, nevertheless, occasionally blended in small quantities with the better sorts by unscrupulous dealers. It is possible, with the aid of the hand-lens, to distinguish the individual outstretched tentacles of the specimen here illustrated. As may be observed, its hinder extremity is inserted within a crevice of the coral rock, into which, on being disturbed, it speedily retreats. In like manner it not unfrequently happens that a dozen or more individuals of this species may be seen protruded to their full length from beneath a hollow coral rock. Such abundant development of the species is, however, most conspicuous farther inshore, where there are but few growing corals, and where the reef is strewn with rock masses torn off and transported from the outer edge of the reef. In all cases, as in the specimen here illustrated, the extended bodies are seen to lie in shallow water.

PLATE XXXIV.

VARIETIES OF TREPANG OR BÊCHE-DE-MER.

This plate illustrates the life aspects of three species of Trepang or Bêche-de-mer, two of which, Nos. 1 and 3, are extensively collected and prepared for the Chinese market, while No. 2 is disqualified in the same manner as the variety associated with the preceding plate, in

consequence of the tenuity of its muscular layers, which shrink to unprofitable proportions in the curing process. Like that form, however, it is occasionally mixed among the better kinds, to augment their bulk. No. 1, *Holothuria sanguinolenta*, much resembles, at first sight, the black species extended in the foreground of the Lady Elliot Island reef-view. It differs from it, however, in several essential respects. In the first place, it does not discharge, when irritated, a stream of cottony-white adhesive filaments, "Cuvierian organs," as does its ally. On the other hand, it exudes a purplish fluid from the surface of its integument when handled roughly. The popular title assigned to this variety of Bêche-de-mer is that of the "Small Lolly-fish." The origin of the title is somewhat obscure, but the name has been apparently applied to it in respect of its near resemblance to an allied species, *Holothuria vagabunda*, known as ordinary, or "Large Lolly-fish," found more plentifully on the outer reef-areas, whose skin surface, when dried, presents the appearance of being divided into roughened lozenge-shaped areas.

The second species of Bêche-de-mer figured, *Holothuria (Bohadschia) argus*, is remarkable for its conspicuous colour ornamentation. The ground tint in this variety is usually bright lilac, superimposed on which tint are chain-like series of rounded or ovate spots of a golden-brown hue; these spots are commonly encircled by adark-brown inner line and a whitish outer line. No two individuals, however, are precisely similar in their pattern of decoration. A coloured illustration of the species is given in Fig. 7 of Plate XII. of the chromo-lithographic series. Like the common black inshore *Holothuria atra*, it discharges a copious stream of tenacious cotton-like filaments when handled, and is of but little commercial use.

The third species illustrated in Plate XXXIV. represents the most valuable marketable variety. The commercial title applied to it is that of the "Teat-fish," the name having reference to the series of mammiform excrescences developed along each side; these are most conspicuous in living examples, but are also more or less prominent in the cured fish. With reference to the peculiar tooth-like armature of the vent, this Bêche-de-mer is referable to the genus Actinopyga; and, in the absence of any discoverable prior intelligible specific description, it is here associated by the author with the combined generic and specific titles of *Actinopyga mamillata*.

PLATE XXXV.

VARIETIES OF TREPANG OR BÊCHE-DE-MER.

Of the two species of Holothuriæ or Bêche-de-mer illustrated by this plate, the upper figure represents a type, *Holothuria coluber*, or the snake-like Bêche-de-mer, that much resembles in aspect and general habits the common black *H. atra*, previously referred to. It may easily be distinguished from that form, however, by the pale primrose-yellow tint of the extensile tentacles, and by the fact that it does not discharge cotton-like Cuvierian filaments when irritated.

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

MADREPORE LAGOON, PORT DENISON.

Its muscular tissues are at the same time, as in the above-named species, so thinly developed that it yields no profit to the curer. A coloured illustration of the anterior portion of this species, with its characteristic primrose tentacles, is given in Chromo plate No. XII.

The second or lower figure in Plate XXXV. illustrates one of the largest and most remarkable of the Barrier series. The specimen when photographed from life was in a contracted state, and is represented less than one half of its natural size. When fully expanded and distended with water it is not unfrequently three or four feet long, and some six or seven inches broad. Its whole dorsal and lateral surfaces are beset with somewhat rosette-shaped or stellate outgrowths of the substance of the integument; these, in their attenuated and flaccid condition, when the animal is lifted freshly from the water, impart to it a fleecy aspect, which renders the organism appropriately comparable to a washed-out strip of a sheepskin doormat. On contraction, as shown in the illustration, these fleshy appendages exhibit clearly an irregularly stellate contour, and are of the same leathery texture as the integument from which they spring. When dried and cured, these appendages assume the aspect of short pointed thorns, and the species is hence known in the trade by the suggestive title of "Prickly" or "Red Prickly-fish," the longer name serving to distinguish it from an allied form denominated "Green Prickly." *Stichopus variegatus* is the scientific appellation of the Red Prickly-fish, and was conferred upon it with relation to specimens originally collected in the South Sea Islands. The colours of this Bêche-de-mer, while subject to an extreme range of variation, are usually associated with a distinctly reddish ground tint, as particularised in the chapter dealing specially with this animal group. Reference may be also made to that chapter for an account of the incident which led to this Bêche-de-mer, once the most valuable of the Barrier Reef species, commanding of late years a very low figure in the Chinese market.

PLATE XXXVI.

NATIVES OF WARRIOR ISLAND, TORRES STRAIT, PREPARING BÊCHE-DE-MER FOR THE CHINESE MARKET.

This plate constitutes a fitting accompaniment to the descriptive account given in a subsequent chapter of the processes employed in preparing and curing the famous Barrier Reef Trepang or Bêche-de-mer for the Chinese market. The scene is at Tud or Warrior Island, once noted for the warlike prowess of its native chieftains, and now one of the most important headquarters of the Bêche-de-mer fishing industry. Situated a little to the north of the centre of Torres Strait, it commands access to the productive Warrior reefs, which extend to within ten miles only of the New Guinea coast. Among the apparatus and appliances conspicuously visible in the accompanying illustration may be noticed the two large cauldrons in which the "fish" are boiled—literally "stewed in their own juice." From the cauldrons they are ladled out with the long-handled net lying on the ground in front of them. The fish are then ready

for manipulation by the natives, who slit them open with a sharp knife and remove the viscera. They are then spread out in the sun for a short interval, previously to being carried to the smoke-house, some of the larger specimens, "Teat-fish," more particularly, being pegged open with short wooden skewers. This is the particular stage of the process represented in Plate XXXVI. Among the other accessories visible in this illustration, attention may be directed to the native bamboo pipe lying, end on, midway between the two figures on the right-hand side, first filled with tobacco smoke by one of the aboriginal belles, and then circulated, after the manner of a "loving cup," among the assembled company. Farther towards the foreground, in the same straight line, is a utensil of universal use in Torres Strait. This is the so-called "Bailer-" or Melon-shell, *Cymbium æthiopicum*, commonly carried in the native canoes for bailing out sea-water, and put to almost as many uses as an Indian gourd.

PLATE XXXVII.

QUEENSLAND PEARLS.

Some idea of the fine size and quality of the pearls produced in the Queensland Barrier district, and more especially from the Torres Strait fisheries grounds, may be gained by a reference to the accompanying plate, portraying the same collection of pearls in two separate positions. All of these individual pearls, thirty-nine in number, were not obtained, as might be imagined, from the single shell on which they rest in the upper figure. They represent the tediously accumulated produce of innumerable mother-of-pearl shells. Not one shell in several thousand produces as fine a gem as any of the three or four of the most perfect specimens included in the top row of the artificially arranged pearl triangle. The two largest and most symmetrical pearls, occupying the first and second positions in this row, weigh some thirty or forty grains apiece, and are worth together, at first sale price, about five hundred pounds. This very interesting little collection was kindly placed at the author's disposal, for this illustration, by Mr. James Clark, owner of one of the finest North Australian pearl-shelling fleets. It represents a small parcel forwarded to him as the supplementary or (so-to-say) unearned increment of a single month's pearl-shelling on one of the most productive Queensland fishing grounds. As explained elsewhere, it is the mother-of-pearl shell that is primarily fished for in Torres Strait, the pearls, when the boat-owner is not also his own diver, being mostly appropriated by the hired diver and the boat's crews.

PLATE XXXVIII.

MOTHER-OF-PEARL SHELLS AND ARTIFICIALLY-PRODUCED PEARL.

The lower figure in this plate represents a mother-of-pearl shell, *Meleagrina Margaritifera*, in that earlier condition of its growth when the external surface of the shell is ornamented with

projecting calcareous laminæ such as give rise to the long spines of what are known as the Thorny Clams, genus Spondylus, which flourish in the same seas. As the pearl shell grows older, the edges of these laminæ become relatively shorter; and finally they disappear, becoming apparently eroded during the growth of the shell substance. This shell represents an individual about twelve months old, and in that period of its existence when it is securely anchored to coral-rock or some other solid fulcrum by a fibrous byssus. Some few of the threads constituting this byssus are left projecting from the intravalvular aperture on the upper right-hand corner of the shell. The colour of the shell in this earlier (or what is commercially known as the "chicken") stage of growth is much brighter than in the older stages. In the specimen here figured, shades of pale green and fawn are attractively blended, the former colour predominating, more particularly, in the neighbourhood of the initial growth centres or umbones.

The upper figure in Plate XXXVIII. will possibly attract notice as representing one of the earliest attempts, associated with some degree of success, to produce a pearl by an operation on the living animal of the marine mother-of-pearl shell. The results attained ages past by the Chinese, by a special treatment of the fresh-water pearl mussel, *Dipsas plicatus*, are probably familiar to every reader The ingenious Celestials, by inserting little leaden images of Buddha, and other subjects, beneath the living membranes of that shell-fish, induced it to invest them with a pearly pellicle. Closely parallel results would probably have been achieved by the same industrious people in connection with the marine species, had they possessed the material to work upon. As shown, however, in the chapter dealing with the pearl and pearl-shell fisheries, considerable difficulty is associated with the initial cultivation of the marine species, with the object of subsequent experimental operations. As in the opening paragraph of Mrs. Glass' classic essay on the art of jugging hare, the difficulty begins with the catching of the hare. Setting aside, for description on a future page, the methods found most efficacious by the author for transporting and cultivating the shell, it may be stated that the pearl represented in the accompanying illustration differs materially from the Chinese productions, in the respect that it is solid pearl throughout, and not a metal or analogous nacre-coated object. It is a true hemispherical pearl capable of excision, from the parent matrix; after the manner of what are known as "bouton" pearls, and it possesses a symmetry and lustre that invest it, by the dictum of experts, with a substantial intrinsic value. As an artificially-produced pearl, it represents a half-way stage towards the production of even more favourable results in the form of freely-detached pearls of equally perfect lustre and irreproachable contour. It has been deemed scarcely fair to speculating schemers, amid these circumstances, to tantalise and disturb their minds with hazy glimpses of a royal road to the rapid accumulation of untold wealth, by a detailed account of the tedious steps that lead to the goal thus far approached. Towards the registration of subscribers to a possible new edition of this book, the publishers may be in a position to hold out the glittering bait—of "a revelation of the

complete process of pearl manufacture." Betwixt this and then lies the "*unbekannte Zukunft*" and an epoch of painstaking work.

PLATE XXXIX.

MANGROVE OYSTERS, KEPPEL BAY, AND THE ENDEAVOUR RIVER.

The two illustrations contained in this plate, representative of what are known in the Australian colonies as mangrove oysters, indicate two widely distinct conditions of oyster-growth. The upper of the two pictures delineates a mangrove oyster-bank, visited and photographed by the author, in Keppel Bay, near Rockhampton, off the estuary of the Fitzroy River. In this instance the oysters started growth attached to the upright shoots, or so-called "Cobbler's Pegs," that spring vertically from the laterally extending roots of the White Mangrove, *Aricennia officinalis*. Around these adventitious supports the oysters have accumulated to such an extent as to form an almost solid bank, between two and three feet thick. The species of oyster that forms these dense aggregations is the ordinary commercial rock-oyster of Queensland and New South Wales, *Ostrea glomerata*, which occurs, in a great variety of forms, from a little south of the New South Wales and Victorian border, throughout Queensland, to the shores of the northern territory. Within the limits of the tropics, and necessarily that oyster-producing area which coincides with the boundaries of the Great Barrier Reef, this oyster is of considerably smaller dimensions than in the southern latitudes where it is most extensively cultivated. The oysters of which the Keppel Bay masses in the illustration are composed rarely exceed two inches in their longest diameter; many being required to satisfy a healthy appetite. These small-sized oysters are now transported in considerable quantities to the southern, Moreton Bay, beds. Spread out with abundance of room to grow and fatten, they begin to grow within a few months, and are in a year or two indistinguishable from the finest Moreton Bay natives.

In the second figure of Plate XXXIX. this same species of oyster, *Ostrea glomerata*, is growing in profusion on the lower moieties of the widely-spreading aerial roots of the orange mangrove, *Rhizophora mucronata*. It was in association with oysters first observed under these conditions that the reports concerning oysters growing upon trees, which for a long while were regarded with suspicion as mere travellers' exaggerations, originated. It has been the author's good fortune to meet, in the northern territory of Western Australia, with a species of oyster which invades the mangroves to a much higher plane, being found not only on the roots and stems, but also on the growing leaves of the mangrove bushes. This oyster is apparently the smallest known. Its shells rarely exceed one quarter of an inch in length, and are so minute that fifty full-grown individuals have been counted on a mangrove leaf two inches long. With

reference to the locality in which it was first discovered—the estuary of the Ord River, Cambridge Gulf, in association with the surveying cruise of H.M.S. *Myrmidon*—the author has conferred upon it the title of *Ostrea ordensis*.* Concerning the illustration of the oyster-encrusted Rhizophora-roots in Plate XXXIX., it remains to be recorded that this scene is taken from the estuary of the Endeavour River, in the neighbourhood of Cooktown. It frequently happens that the mangrove roots are encrusted with oysters very much more densely than is here shown. Unfortunately, the author was not armed with his camera when exploring such more prolific mangrove thickets.

PLATE XL.

(A.)—OYSTER-REEF, KEPPEL BAY.

A third and very distinct condition of the ordinary Australian rock oyster, *Ostrea glomerata*, is afforded by this picture. In this instance the molluscs form a solid reef-like mass, several feet in thickness, and of indefinite extent. The considerable portion that has been undermined and broken up by the tidal currents displays the dense aggregation of the oysters with remarkable distinctness. This prolific oyster-reef, in common with the mangrove oyster-bank in the preceding plate, belongs to the Keppel Bay, or Rockhampton, district, representing an area in the shallow, mangrove-bounded, channel known as the "Narrows," which unites Keppel Bay with Port Curtis. This oyster-reef, as here portrayed, represents the condition presented at extreme low tide, the whole of it is completely covered at about half-tide level. Oyster-reefs of similar extent and thickness were formerly plentiful in Moreton Bay; but they have, for the most part, been broken up and utilised as "brood ware" by the oyster cultivators. When massed together under natural conditions, these reef oysters remain permanently dwarfed, whereas on being broken apart, and distributed over the cultivation banks, they speedily grow to marketable shape and size.

(B.)—CORAL-ROCK OYSTERS.

The species of oyster that thickly encrusts the rocks in this illustration, is altogether distinct from the one depicted in the preceding views. While that type, the ordinary Australian commercial rock oyster, is invariably found where there is either permanently or periodically a considerable admixture of fresh water, the present form, technically distinguished by the

* "Oysters and Oyster Cultivation at the Antipodes." By W. Saville-Kent, F.L.S. Communicated to the Wellington New Zealand Meeting of the Australian Association for the Advancement of Science, January, 1890.

title of *Ostrea mordax*, flourishes in the purest salt water, attaining its maximum development on the storm-stranded coral-masses, or natural rock formations, at about half-tide mark, of the reef islets and mainland foreshores throughout the Great Barrier district. The illustration represents aggregations of the species encrusting rock boulders and eroded coral-stocks on the foreshore of one of the Northumberland Islands group, lying some twenty miles eastwards of Mackay. Conspicuous in the interstices that separate the rocky boulders from one another may be observed the accumulated *débris* of Stags'-horn and other branching corals. More distinct illustrations of this species, which, with relation to its most characteristic habitat, is distinguished in this volume by the title of the "Coral Rock Oyster," will be found in the Chromo-lithographic plate No. XIV. The remarkable variety of this species, described in a later chapter, that has the attached valve developed in an elongate, camerated, fashion, after the manner of *Ostrea cornucopiæ*, is illustrated in the same plate.

PLATE XLI.

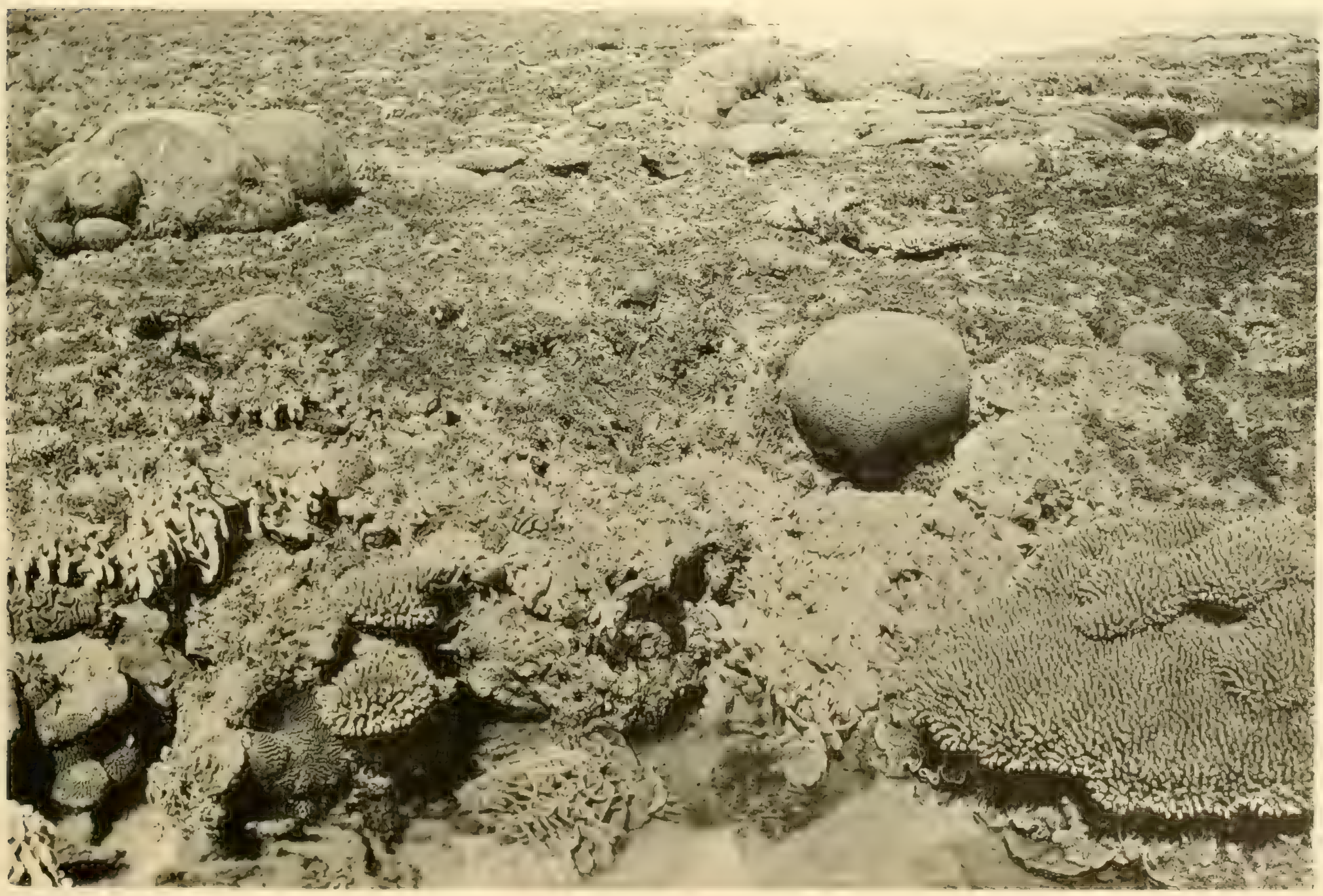
(A.)—CULTIVATED OYSTER-BANK, MORETON BAY.

Both this and the succeeding picture represent conditions of growth of the commercial species of oyster, *Ostrea glomerata*, that is illustrated in the two preceding plates. This particular illustration depicts one of the natural Moreton Bay oyster-banks, some little distance south of the Barrier district, that is utilised for the systematic cultivation of the mollusc for the Brisbane and Sydney markets. In their natural condition the oysters on this bank are attached in clusters to ironstone pebbles. The bivalves grow, however, to larger dimensions, on being separated and distributed in such manner that they can obtain a more abundant food supply, and having sufficient space around them to allow of their fullest symmetrical enlargement. As recorded in the descriptive account of the Keppel Bay oyster-reef, it is to extensive level banks of this kind that the small, closely-crowded, reef and mangrove oysters from the *boná fide* Barrier latitudes are transported and successfully cultivated.

(B.)—WHELK OYSTER-BANK, MORETON BAY.

To the uninitiated, the oyster-bank that forms the subject of this illustration possesses no special feature to distinguish it from the preceding one. A very important point of divergence, however, is embodied in the fact that ironstone pebbles, or other rock formations, are entirely absent, and that the thickly-associated oysters are almost universally attached to a species of so-called "oyster-whelk," *Potamides ebeninus*. In their primary condition of attachment, in the form of spat, the oyster-whelks are alive, and travel freely over the surface

No. 1. SUBMERGED MILLEPORA, PALM ISLAND'S REEF.



W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

No. 2. LOPHOSERIS REEF, PORT DENISON.

of the bank in search of the smaller algæ on which they feed. As the oysters increase in size, the unfortunate whelk becomes proportionately weighed down, and hampered in its movements, being finally asphyxiated in the muddy covering of the bank, or condemned to pass the rest of its miserable existence chained to the spot to which, doubtless in pain and anguish, it ultimately dragged its weary "foot." The burden of oysters that one of these small univalve shells can carry, and yet survive, is astonishing. This whelk-shell, with the animal it contains, weighs, on an average, about two ounces, while its load of oysters scale over a pound. Sinbad the Sailor, with his tight-clinging "Old Man of the Sea," was an object of envy in comparison. Examples of *Ostrea glomerata* associated in this same manner with Potamides, have been observed by the author as far north as Cairns, and at many stations further south within the Great Barrier district. Further details of this and various other characteristic forms of this protean and commercially valuable bivalve are included in the special chapter on oysters.

PLATE XLII.

BARRIER REEF SHELLS.

The photographs reproduced in this plate have been selected with the object of representing a few of the larger and more conspicuous of the rich variety of shells indigenous to the Barrier district, together with that of illustrating the economical, and decorative uses to which many of the species can be applied. The upper figure depicts a specimen which invites special attention. This is the flat, irregularly-margined, tray-like object in the foreground that is utilised as a receptacle for the collection of smaller shells. This object is a sponge—not one of soft, delicately-fibrous nature, like our familiar "Companion of the Bath," but composed of a dense mass of minute silicious spicula, so welded together with organic matter as to resemble virgin cork in aspect and texture. This sponge was obtained for the author from what is known as the "old ground" in Torres Strait, by one of the pearl-shell divers. Its systematic position among the vast assemblage of many hundred genera of sponge forms known to naturalists is akin to that of the so-called "Neptune's goblet" (or "Neptune's cup") sponge, *Raphyrus Griffithsi*, obtained chiefly from the seas throughout Polynesia, and commonly growing, in the form of an erect cup, or vase, with a distinct supporting stem, to the height of two or three feet. This flattened-out, tray-shaped specimen had no distinct footstalk. It was simply attached by its under surface to the sea-bottom. Superiorly, it is singularly modified so as to form two superimposed smaller trays, which in the illustration are filled with the smallest shells. The addition of an ordinary tripod-stand was alone requisite to convert this remarkable sponge into a highly efficient show-table for marine objects.

Proceeding to an examination of the shells, the main subject of this illustration, we find that the series massed together in the background includes some of the largest and most characteristic Barrier district types. On the extreme left is a ponderous Helmet shell, *Cassis cornuta*, weighing about eight pounds, and over fourteen inches long. It represents a group of shells extensively used in the manufacture of cameos. A little below it, to the right, is a Melon or Boat shell, *Cymbium æthiopicum*, of even larger proportions, including within its capacious cavity a large specimen of the rare pearly Nautilus, *Nautilus stenomphilus*. This Melon shell is held in high esteem by the Torres Strait and Barrier-district natives, being used by them, as has been previously related, as a bailer for their cranky canoes and for many other purposes. Two mother-of-pearl shells, *Meleagina margaritifera*, of the largest size, weighing respectively six and seven pounds, form the immediate background to the series. Two examples of what are known as Spider, or Scorpion shells, genus Pteroceras, conspicuously recline against the right and the left peripheries of the two pearl shells. The species to the left represents the exceedingly common seven-spiked *P. lambi*, and that to the right the rarer six-armed *Pteroceras chiragra*. Both species, although the last-named one more particularly, are notable for the brilliant pink lining of their shell apertures.

Farther towards the right, in this same illustration, there occurs, standing obliquely on end, one of the large variegated Triton shells, *Triton tritonis*, which, with a circular hole about half an inch in diameter, bored a few inches from the pointed apex, is used as a trumpet by the natives of Torres Strait. The deep, sonorous, blast that can be evolved by a pair of healthy native lungs from the recesses of this grand conch would arouse the "Seven Sleepers," and the ghosts of all their ancestry. It is stated in many natural history works that the sound is obtained from the shell by laying it to the lips, and blowing across the punctured hole after the manner of playing a flute. The blast is actually produced by covering the hole completely with the mouth, and blowing as when sounding a bugle. The large Helmet shell, Cassis, is bored at its apex, and similarly employed as a wind instrument by the Torres Strait natives. The shell, with an elongate spout-like projection of its margin, technically termed the siphon, that occupies an oblique position immediately beneath the Triton, represents one of the largest known Gasteropods, or snail-like molluscs, and is, with reference to all essential structural details, very nearly related to the European Red-whelk, or "Buckie," *Fusus antiquus*. "Spindle" shells, on account of their suggestively tapering contours, represent the collective name by which the hundred or more discovered specific varieties of this genus are known to conchologists. Among these the giant of its tribe, now under notice, is distinguished by the title of *Fusus proboscidiformis*. The particular specimen in the author's possession, here figured, is only one inch short of two feet. Two specimens of the large white Murex, or Woodcock, shell, *Murex ramosus*, and a Pearly or Tiger Nautilus, *Nautilus pompilius*, complete the list of the larger group in the background.

Respecting the Nautilus, it is worth remarking that, although the shells are cast in some abundance on the island beaches of Torres Strait, and the northern portion of the Barrier, the living tenant is very rarely seen there. Direct evidence, including that obtained by the *Challenger* expedition, points to its being an essentially deep-water species, the only living example obtained throughout that scientific cruise being one that was dredged up off Matuka Island from a depth of 320 fathoms. At the same time, there are many older records, dating from the time of the Dutch naturalist, Romphius, 1705, testifying to the Pearly Nautilus having been taken at Batavia, the Moluccas, and the Thousand Islands of the Malay Archipelago, in the crab and crayfish pots set by the natives, in comparatively shallow water. A single, somewhat doubtful, instance of the occurrence of the living animal, has fallen within the author's experiences in Australian seas. This was in blue, abyssal, water off the northern territory, midway between Cambridge Gulf and Port Darwin, when the author was returning on board H.M.S. *Myrmidon*, after accompanying the vessel's surveying cruise to the first-named locality. While we were seated at breakfast the watch reported that a Nautilus shell, "containing something that looked very much like a cauliflower," had drifted past the ship's side. With the enthusiasm that distinguished him on all occasions when a scientific issue was at stake, the Commander, the Hon. H. P. Foley Vereker, R.N., immediately "wore" the ship, and had a boat lowered, with the object of capturing the prize. To our great chagrin, the quest was unsuccessful, the creature, apparently alarmed by the wash of the screw, having taken soundings. That the animal which floated past was a live Nautilus, there seemed little or no reason to doubt, in face of the rough but very pertinent description of the object reported by the blue-jacket.

The sponge table in the foreground of this illustration supports a collection of the lesser ornamental shells of the Barrier region, too numerous to enumerate individually. Smaller mother-of-pearl shells, belonging to the several varieties described in the pearl-shell-fishery chapter, are posted in the front, one of these, towards the left, having erected vertically against it the typical example of the abnormally elongate oyster, *Ostrea mordax*, var. *cornucopiaformis*, delineated in its natural size in Plate XIV. of the chromo-lithographic series. The heterogeneous mass of smaller shells that fills up the more posterior recesses of the sponge includes numerous representatives of the genera Ovulum, Conus, Cypræa, Strombus, Voluta, Pterocoras, Melo, Oliva, Dolium, Harpa, Murex, and many others. The Spotted or Tiger cowries, *Cypræa tigris*, are present in abundant variety in this series, and represent one of the commonest forms in the reef. The rarer dark-mahogany or almost black-mouthed species, with pale yellow spots, *Cypræa mauritiana*, and the ocellated *C. argus*, also find place in the collection. The pure glossy white shells of the "Poached-egg" or porcelain shell *Ovulum ovum* are likewise conspicuous. This species is extensively used by the natives of Torres Strait, New Guinea, and the Barrier district generally, for the decoration of their canoes, and in the manufacture of articles of personal adornment.

The lower figure included in Plate XLII. is introduced in order to illustrate various highly artistic designs for utilising some of the shells of the Great Barrier district. Trumpet shells, the large white Murex, Frilled and Bear's-foot Clams, Hippopus, and "Green Snails," *Turbo olearius*, are mounted on admirably-executed, imitation, red coral stands. Either singly or in artistically arranged groups, these coral-mounted shells lend themselves with remarkable suitability to the purposes of table decoration. The larger groups, fashioned in the form of epergnes, constitute graceful central ornaments for the reception of flowers or fruit, while the single specimens have a most pleasing effect when planted with miniature ferns and lycopods. Introducing a few other shell devices, you can produce a very elegant and unique decorative suite. The mother-of-pearl shells, for example, polished and mounted on short feet, which may be most appropriately turned in mother-of-pearl, constitute remarkably handsome dessert dishes or plates. Finger-bowls and larger fruit-stands may be constructed of single Clam-shells, six or eight inches in diameter, while smaller valves of the same genus make excellent salt-cellars. The pale-yellow frilled variety, *Tridacna Cummingii*, is particularly eligible for this purpose. The directions in which this artistic adaptation of Nature's products can be developed is almost unlimited, and to anyone possessing a suitable collection of shells the suggestion may prove acceptable. Among other shells indigenous to the Barrier district not previously referred to in this association, the glossy white "Poached-egg" shells, *Ovulum ovum*, as also many of the beautifully spotted cowries, form, when reversed, elegant receptacles for small, short-stalked flowers, such as violets. It only remains to be mentioned that the originator of the shell designs here illustrated, is Mr. C. Williams, King Street, Hammersmith, who has from this central depôt laid the foundation of a steadily increasing trade that is receiving substantial support at special industrial exhibitions and sea-side resorts. In addition to making his own original designs, Mr. Williams undertakes the mounting, with the same durable coral-like material, of suitably selected specimens from his customers' cabinets. The author hopes that this brief notice of their adaptability may lead to a fuller development of the trade in decorative Australian shells.

PLATES XLIII. TO XLVIII.

BARRIER REEF FISHES.

The subject-matter of these last six plates of the photo-mezzotype series, is so fully dealt with in a specially written chapter as to demand only a passing notice here. The distinctly-printed, popular and technical names, appended to each fish figured, suffice to indicate their respective identities. It may, however, interest readers to observe that these illustrations are reproductions of photographs executed by the author from, in almost all instances, fish taken freshly out of the water, and in many cases alive. It is due to this fact that the fins

are, in the majority of the figures, untorn and naturally posed, while the jaws and eyes lack that *post-mortem* distortion and the inane expression commonly noticeable in pictures of fish. The results presented, indicate the efficiency of the method employed, which possesses a distinct advantage, as compared with ordinary lithographs, in both the matter of cost, and the accurate reproduction of minute detail. In fish-photography, as practised by the author, the camera is fitted vertically, in conjunction with the special form of stand described and illustrated in association with Plate XVII.

The figures introduced below as a tail-piece to this chapter do not belong to the series illustrating the fish-fauna of the Barrier Reef proper, referred to in the preceding paragraph. They represent two fresh-water species of high scientific interest peculiar to Queensland, referred to in the fish-descriptive chapter under the respective titles of *Osteoglossum Jardinei*, and *Ceratodus Forsteri.* Both of them, in common with the Giant Perch, *Lates calcarifer*, Plate XLIII., Fig. 1, are locally associated by colonists with the name of Barramundi, that appears to be applied by the natives to a variety of large fresh-water fish. The title, in its restricted sense, belongs rightly only to the members of the genus Osteoglossum.

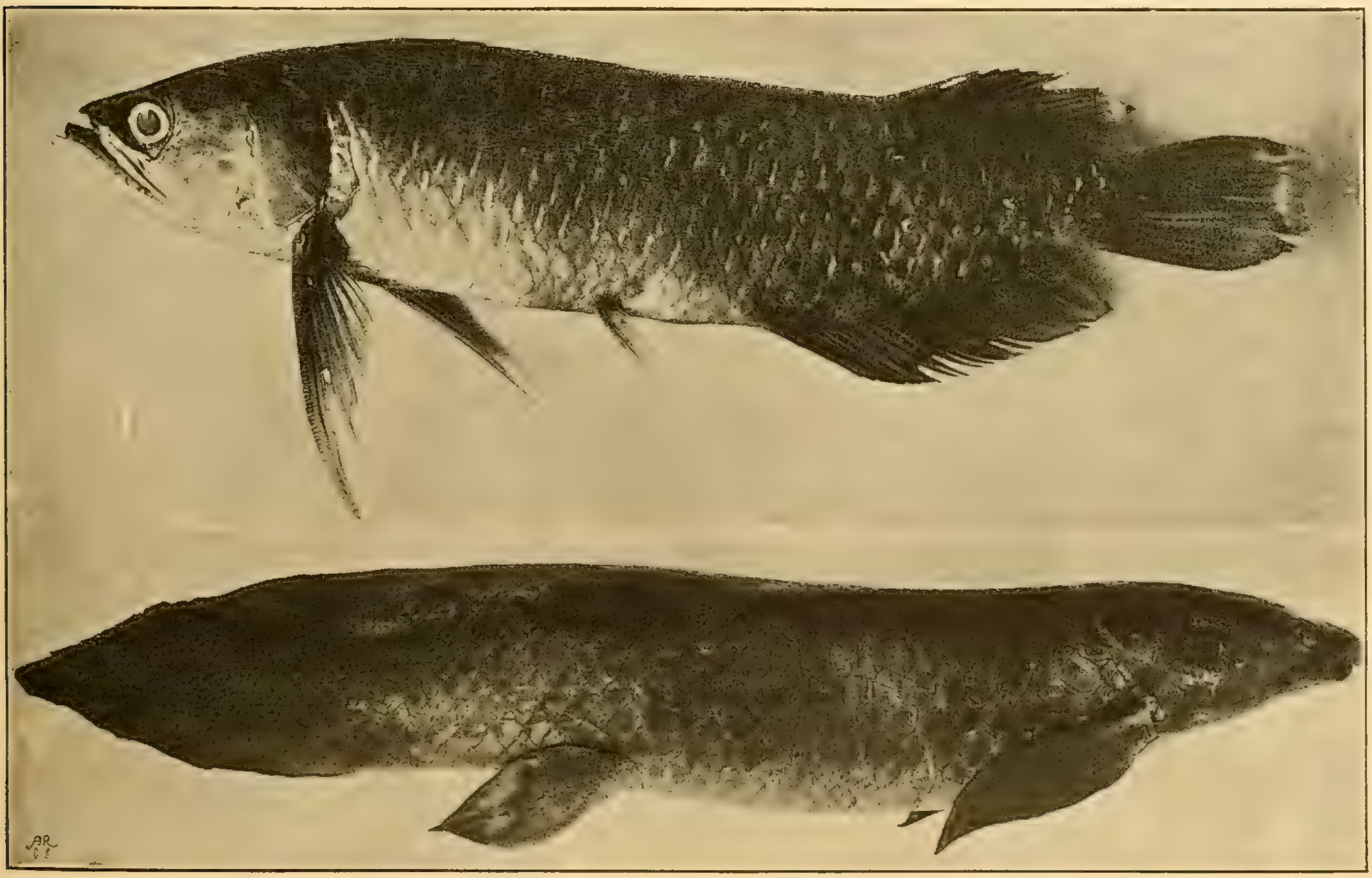


FIG. 1. JARDINE'S BARRAMUNDI, *Osteoglossum Jardinei*, S.K., $\frac{1}{4}$ NAT. SIZE.
FIG 2. CERATODUS, OR LUNG FISH, *Ceratodus Forsteri*, KREFFT, $\frac{1}{6}$ NAT. SIZE

CHAPTER II.

CORAL-REEFS, THEIR GENERAL STRUCTURE, AND THEORIES OF ORIGIN.

A SLIGHT deviation is here made from the original intention to proceed forthwith with a description of the structural features of the Great Barrier Reef of Australia, together with an examination of the conditions under which, apparently, this vast coral edifice was primarily produced. In order to make the general reader able to follow the details given, and to assist him towards forming a clearer judgment concerning the evidence hereafter to be submitted, it has been thought desirable to devote a short preliminary chapter to a brief outline of the more generally recognised elements and modifications of coral-reef structure, supplementing such details with a *précis* of the newer interpretations that have of late years been associated with coral-reef formation.

For the information of those by whom the subject of corals and coral animals is approached for the first time in this volume, it is necessary to begin with a descent into elementary details, which the accomplished specialist will of necessity skip. In the first instance, it is, perhaps, incumbent to define the correct significance of the terms "corals" and "coral animals." Notwithstanding the wide diffusion of knowledge, which includes a smattering of many "'ologies," it is astonishing to find how tenacious an influence ancient tradition concerning coral organisation still exerts on the public mind. The poetic fallacy of coral-reefs being built up by an association of "insects" between which there subsists a relationship analogous to that which obtains between "the busy bee and its waxen cell" is frequently enunciated from the pulpit, and in the pages of the daily newspapers.

Doubtless, there is a large section of the public whose zoological lore will ever remain restricted to the narrow limits of that of *Punch's* railway porter, who, puzzled as to the classification of the old lady's tortoise, declared that, being "neither a dawg nor a bird, it must needs be a hinsec." There is also a very large multitude to whom the term "insect" includes everything not distinctly referable to the category of "flesh, fowl, or

good red herring," spiders, *par excellence*, being with them prominent representatives of this popular omnium-gatherum class. Insects, in the technically accepted interpretation of the term, embrace invertebrate animals which in their normal adult condition possess no more, no less, than six jointed ambulatory limbs, or legs, associated with a distinctly articulated body, and a complex nervous, circulatory, and visceral system. The coral animal owns none of these. It is, individually, a simple polyp, comparable in every essential detail with the ordinary simply-organised sea-anemone familiar to every seaside or aquarium visitor, with the exception that it possesses the property of secreting a dense, calcareous, skeleton out of the lime held abundantly in suspension in probably every sea. On the British coast, even, there are a few known coral-secreting anemones, such as the Devonshire Cup-coral, *Caryophyllia Smithii*, and the scarlet and gold Cup-coral, *Balanophyllia regia*. In the tropical, coral seas there are corresponding solitary species, such as the Mushroom-coral, genus Fungia, illustrated by Plates XXIV., XXV., and Chromo No. VI., which particular type might be appropriately likened to a coral-forming anemone, resembling our largest British species, known as the "Dahlia anemone," *Tealia crassicornis*. This calcareous skelton, the possession of which, it should be mentioned, constitutes the most marked distinction betwixt a coral and a sea-anemone, is secreted entirely by the basal tissues of the polyps. The polyps consequently, as shown in some of the accompanying coloured plates, are able, through abundant ingestion of, and distension with, water, to elevate their tentacular crowns to a considerable height above their associated corals.

Without entering into a detailed account of the more conspicuous structural variations of corals and their polyps, which furnishes the material for a subsequent chapter, the author may remark that the reef-forming corals owe their solidity and extensive dimensions to the fact that they represent, for the most part, the united, or, more correctly, imperfectly separated, coral skeletons or "coralla" of a great number of closely associated sea-anemone-like polyps. The closely aggregated clusters of our commoner British species, such as the strawberry, *Actinia mesembyanthemum*, the daisy, *Sagartia bellis*, and the opelet anemone, *Anthea cereus*, as they repose extended in their beauty in some clear rock-pool on, say, the Devonshire, Welsh, or Channel Islands coast, have been a frequent source of admiring wonder. The majority of the clusters have been formed by the repeated subdivision, or technically-termed "fission," of a single primary anemone or polyp. Supposing that these clustered anemones secreted a calcareous coral basis, and, in place of becoming entirely separated from one another, remained united by their basal, skeleton-secreting tissues, we should have in this hypothetical compound organism a precise presentment of the structural organisation of a typical reef-forming coral. This brief introductory explanation will, it is trusted, suffice to inculcate a tolerably correct and intelligible apprehension of the true nature and affinities of the long-suffering, reef-constructing "coral insect."

The coral-reef-building polyps, it is tolerably well known, are practically confined to the seas of the tropics, as limited by the parallels of latitude of $23\frac{1}{2}°$ north and south of the Equator. The main factor in their distribution is that of a uniformly high temperature, which, in the coldest winter months, shall not fall below that of 68° F. Isothermal lines, coincident with this temperature, are found, however, to be by no means in precise harmony with the above latitudes. On the west sides of the large continents of Africa and South America, in particular, the southern isothermal line is thrust high up towards, and in the latter instance actually to the north of, the Equator. On the Australian continent, as given in J. D. Dana's isothermal chart,* these limiting lines of tropical temperature are practically uniform with that of 26° S. latitude on both the eastern and the western shores, dropping down, however, as low as 30° some little distance off the eastern coast. As a matter of fact, a few reef-corals are found in Moreton Bay, in latitude 27°, while the most southern living reefs are those which surround Lady Elliot Island, just north of latitude 24°. One species of reef-coral, *Plesiastræa urvillei*, has been obtained in Port Jackson, close to Sydney, New South Wales, just above the latitude of 34° south; and an allied species, *P. Peronii*, has been reported by Mr. Tenison-Woods as occurring at various points along the south coast of Australia in latitudes as low as 38° and 39°. This genus apparently represents the most southern Australian representative of the reef-forming class, though there are, as in the European, or even in the British, seas, several solitary, temperate or cold-water types.

The proportion that the growing corals bear to the aggregate reef-masses is very small. On such a reef, by way of example, as the one represented by Plate XXX., depicting the scene of the wrecked mission schooner *Harrier*, and marked on the Admiralty charts as F reef, the view altogether lacks the luxuriant crops of living corals that characterise the majority of the reef-scenes selected for the illustration of this work. The lower figure of the same plate affords an almost parallel illustration of a reef devoid of visibly growing corals, the lifelessness of its general superficies being further accentuated by the huge rock-masses torn off the edge and thrown high upon the surface of the reef. The interpretation of the phenomena is that the soft, moist, anemone-like polyps that lay the foundations of these vast reefs cannot survive the long exposure to the evaporating action of the tropical sun, that would be inevitably associated with their growth at this high plane of elevation, and that, as a matter of fact, represents low-water conditions at an ordinary neap-tide. The living corals in these reef-scenes lie entirely out of sight, and at a lower depth, on the outer margin of the reef. The constituent elements of the reef-areas visible in the two illustrations referred to, represent the consolidated wave-, storm-, and current-accumulated *débris* of decayed or broken-down corals originally detached from the outside growing margin. And this same constructive formula expresses a dominant peculiarity of the majority of living coral-reefs.

* J. D. Dana, "Corals and Coral Islands," p. 298. 1872.

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

WARRIOR ISLAND REEF. TORRES STRAITS.

This highly characteristic structure of the larger reef-masses, typified by a relatively large dead and weathered central core, associated with a comparatively small and narrow peripheral zone of vitality, is anticipated in an instructive manner by the developmental history or ontogeny of an individual coral-stock depicted in several of the accompanying photographic reef-views.

The massive growths of Goniastræa in the lower figure of Plate IV. illustrate this phenomenon most conspicuously. The foreground coral-stock, in this instance, perfectly typifies those varieties of coral-reefs in which the central area is almost entirely dead, and weathered by exposure to sun and air. The lower figure of Plate V., and the corresponding one of Plate VI., reproduce in miniature, in like manner, those numerous reefs in which, while the peripheries represent the essential growing zones, the dead and weathered horizontal central areas support scattered patches of coral species distinct from that of their own basal mass, which in these two instances is a species of Porites. Those reefs in which growing coral is developed almost uninterruptedly over extensive areas, as illustrated more particularly by such plates as Nos. XII. and XVII., are very rarely laid bare by the receding waters, and then only during abnormally low spring or (so-called) "king-tides."

The highest elevation at which corals are found growing in the Barrier district is that of about ordinary low-water mark. Thence downwards, to a depth of some twenty or thirty fathoms, represents the generally recognised bathymetrical range of reef-coral growth. Their most luxuriant development, however, is limited by a depth of about fifteen fathoms from low-water—an area that corresponds essentially with what is known as the Oar-weed or Laminarian zone of European and other temperate seas. Quite recently, a limited development of reef-corals, as represented by the genus Madrepora, has been found at a depth of from forty to forty-five fathoms—the area of this abnormal growth was the Macclesfield and Tizard banks of the China seas. The reef-corals obtained from this depth exhibit a distinct aspect as compared with those of the shallower-water zone, being, as a rule, of much slighter build.

There are not a few Madreporaria, or Stony-corals, whose growth-zone is coincident only with the cold deep water, and abyssal depths, of from one hundred to between two and three thousand fathoms. The species occurring at the greatest depths are, for the most part, simple or solitary species of extreme tenuity, which could exert no material influence on reef-construction. However, within the more moderate soundings of from one hundred to five or six hundred fathoms, there exist, even in European seas, conspicuous species whose deep-water habitat alone excludes them from participating substantially in the work of reef-building. Dendrophyllia, Lophohelia, Amphihelia, and other allied genera form massive branching coralla, or thick bushy growths, extending over large submarine areas which, if raised above the surface, would present as luxuriant and picturesque a reef-scape as is shown by

Plate XII. and many other of the most characteristic reef-views illustrated in this volume. In "The Depths of the Sea," by the late Sir C. Wyville Thomson, who gives an account of the general results of the dredging cruises of H.M.S. *Porcupine* and *Lightning*, during the summers of 1868, 1869, and 1870, the occurrence of *Lophohelia prolifera*, accompanied by more sparing growths of as many as five species of Amphihelia, is reported as occurring in regular banks along the west coasts of Scotland and of Ireland at depths varying from one hundred and fifty to five hundred fathoms. In another paragraph, p. 168, of the same work, the first-named type, Lophohelia, is described as "forming stony copses which cover the bottom of the sea for many miles." In the dredging cruise of Mr. Marshall Hall's yacht, *Norna*, in the month of May, 1870, in which the author, then attached to the Natural History Departments of the British Museum, participated, both Lophohelia and Amphihelia were obtained in abundance in depths of five hundred and six hundred fathoms, off Setubal, on the coast of Portugal. Associated with these were robust tree-like growths of the Eupsammian type, *Dendrophyllia ramea*, whose ramifying coralla averaged three or four feet in height, and were as massive and weighty as any of the most solid branching Madreporæ of the Great Barrier Reef. It is worthy of remark that this genus Dendrophyllia is one of the representative Barrier Reef genera. It is illustrated in Chromo plate No. VIII. by a form whose orange and scarlet polyps are indistinguishable in shape and colour from those of the deep-sea type.

A question very naturally arises, at this point, as to how it is that, with such an abundant development of Stony-corals at these profound depths, coral-reefs are not formed in deep water. Were such a thing possible, the western coast-lines of the British Isles and the Iberian Peninsula would be as thickly girdled with coral-reefs as those of India or Australia. A logical interpretation of their absence can be found only in the fact, to which scarcely sufficient prominence has been hitherto given, that the solid coral-rock, of which, as explained in a previous page, the greater mass of all coral-reefs is composed, is constructed, exclusively, in tropical areas subject to alternations of complete submersion and atmospheric exposure with the rise and fall of the tide. It is necessarily conceded that the massive dome-shaped corals, such as the Poritidæ and Astreaceæ, which are entirely absent in abyssal depths, contribute substantially towards the formation of the generality of reefs. However, it needs but a glance at the photographic reef-views reproduced in this volume,—notably at those of Plate V., No. 1, and Plates IX., XI., and XII.,—to demonstrate the fact that the above-named massive-growing corals may be very sparingly represented, or even altogether absent, throughout reef-areas of unlimited extent. The thicket-growths of the deep-sea Lophohelia, Amphihelia, and Dendrophyllia would act with equal efficiency as reef-builders if they were capable of translation to this higher, tidally-affected, plane. The solid coral-rock, which represents the chief constituent of all reef-masses, is, as previously remarked, composed exclusively of the broken-down, more or less triturated, and subsequently re-consolidated, calcareous elements of the peripherally

growing corals. The coral species that contribute the most extensive supply of calcareous material to this reef-rock-manufacture are, beyond question, the more fragile and relatively quick-growing species of Madrepora, and other branching varieties, upon which the storm waves strike with most destructive force.

We have now reached the point in this chapter which is the most eligible for an enumeration of the more distinct descriptions of coral-reefs that exist, together with an examination of the somewhat divergent theories that have been adduced concerning their respective origins. By far the most lucid and intelligible description of the various classes of these structures, combined with a logical exposition of their mode of origin, is undoubtedly that contained in the classical treatise on "The Structure and Distribution of Coral-Reefs," by Mr. Charles Darwin, published in the year 1842, which work may be said to have laid the foundation of the imperishable reputation of that distinguished naturalist. Within the last decade some of the more important of Darwin's theories of coral-reef formation have been vigorously attacked, so much so that at the present day there are divided biological camps regarding the tenability or otherwise of the Darwinian interpretations. Such being the case, it has been deemed advisable by the author to enter at some considerable length into an examination of the conflicting evidence adduced, and to quote largely from the writings of the authorities at variance.

The specific varieties of coral-reefs that receive universal recognition at the hands of biologists are, as originally classified by Mr. Darwin, referred to three distinct categories. These are denominated respectively as—1, "Lagoon-Islands" or "Atolls"; 2, "Barrier" or "Encircling-Reefs"; 3, "Fringing" or "Shore-Reefs." The Lagoon-Islands or Atolls, in Mr. Darwin's own words, are "vast rings of coral-rock, often many leagues in diameter, here and there surmounted by a low verdant island with dazzling white shores, bathed on the outside by the foaming breakers of the ocean, and on the inside surrounding a calm expanse of water, which, from reflection, is generally of a bright but pale-green colour." Occasionally the entire ring of coral-rock is surmounted by an uninterrupted circle of upraised vegetated, inhabitable land; more frequently, the coral-rock ring includes a number of irregularly detached islets; while in innumerable instances the rock-circle with the enclosed lagoon is entirely submerged at high tide, and only indicates its existence by the presence of broken water around its periphery, and by the characteristic emerald-green tint of the water that overlies its superficies. The contour of these atolls may vary in form from an almost perfect circle, or oval, to every conceivable pattern of irregularity, and, in dimensions, from a few hundred yards to a diameter of over eighty miles. Milla-dou-Madon, in the Maldiva Archipelago, of an irregular elongate outline, is cited in Mr. Darwin's work as being no less than eighty-eight miles long by a little less than twenty broad. In these atolls, where the enclosed lagoon is more or less completely surrounded by a ring of elevated land, there is usually a channel

communication with the sea, such opening being invariably situated on the more sheltered or lee-side. In the largest atolls this passage is of such a depth that large vessels can gain entry by it. The origin and significance of the passage is clearly discernible in the small atolls, where it constitutes a simple gutter-like channel for the escape of the impounded water on the fall of the tide. The embankment of coral-rock on this lee-side is lowest and thus constitutes the area of least resistance. The prevailing wind, moreover, the south-east monsoon, drifts the enclosed water throughout the greater portion of the year towards the natural opening.

The reef formations referable to the second series in Mr. Darwin's classification are those of the "Barrier" or "Encircling" type. His descriptive diagnosis of this modified variety, is as follows:—"The term 'Barrier' has been generally applied to that vast reef which fronts the north-east shore of Australia, and by most voyagers likewise to that on the western coast of New Caledonia. At one time I thought it convenient thus to restrict the term; but, as these reefs are similar in structure and in position, relatively to the land, to those, which, like a wall with a deep moat within, encircle many smaller islands, I have classed them together. The reef, also, on the west coast of New Caledonia, circling round the extremities of the island, is an intermediate form between a small encircling reef and the Australian barrier, which stretches for a thousand miles in nearly a straight line." In a concluding summary, Mr. Darwin remarks: "After the details now given, it may be asserted that there is not one point of essential difference between encircling barrier reefs and atolls. The latter enclose a simple sheet of water; the former encircle an expanse, with one or more islands rising from it." A highly characteristic feature of all barrier reefs—whether flanking an island-continent, as in the case of Australia, or encircling a small islet, as in that of Bolabola, in the Society Group—specially quoted by Darwin—is that the descent into deep water from their outer margin is very abrupt. Along the Australian Great Barrier, soundings of over a hundred fathoms, which rapidly shelve into abyssal profundity, occur in close proximity to the interior margin that has no greater a depth than thirty or forty fathoms. While this same peculiarity characterises most of the lagoon-islands, or atolls, of the Pacific and Indian areas, different conditions, as hereafter shown, may be associated with certain of those of the Australian region.

Fringing, or shore-reefs, which represent the reef structures of the third order recognised, are thus described by Mr. Darwin:—"Fringing-reefs, or, as they have been called by some voyagers, shore-reefs, whether skirting an island or part of a continent, at first appear to differ little from barrier reefs, except that they are generally of less breadth. As far as the superficies of the actual reef is concerned, that is the case; but the absence of an interior deep-water channel, and the close relation in their horizontal extension with the probable slope of the adjoining land beneath the sea, present essential points of difference." In another paragraph, the same authority writes:—"With

respect to fringing, or shore-reefs, there is little in their structure which needs explanation; and their name expresses their comparatively small extension. They differ from barrier reefs in not lying far from the shore, and in not having within them a broad channel of deep water. Reefs, allied in most respects to fringing-reefs, also occur around submerged banks of sediment and of worn-down rock; and others are scattered quite irregularly where the sea is very shallow."

With the assistance of the foregoing authoritative and generally accepted statements, the reader, voyaging in coral seas, should experience no difficulty in assigning such reefs as he may explore to their proper categories. Progress may now be made towards an enumeration and examination of the somewhat varying constructive interpretations that have been associated with their origin. The fringing-reef, *per se*, presents no constructive difficulties; its origin, as an in-shore or shallow-water coral-bank, which has sprung up wheresoever the depth and associated conditions are favourable to its development, being clearly apparent. It may, nevertheless, as presently shown, represent the initial growth of the two other more complex reef modifications. Passing on to the consideration of the lagoon-islands, or atolls,—"those singular rings of coral-land which rise abruptly out of the unfathomable ocean," as Mr. Darwin elsewhere describes them—we enter into the arena of fierce debate. Prior to Darwin's explanation, the theory of atoll formation most generally received was that atolls were based on submarine craters. The untenability of this theory was, however, clearly demonstrated by Mr. Darwin, who pointed out that the abnormal size and shapes of many of the most typical atolls precluded such an interpretation. Bow atoll, which is five times as long as it is broad; Menchicoff Island, with three loops, together, sixty miles; Rimsky Korsakoff, narrow, crooked, and fifty-four miles long; and, finally, Milla-dou-Matte, in the Maldiva atoll group, eighty-eight miles in length and from ten to twenty broad, are cited as being entirely incompatible with a crater origin. A still more valid objection to the acceptance of the "crater" interpretation is associated by Mr. Darwin with the fact that, in order to establish its truth, all of the innumerable atoll-bearing centres would have to lie at approximately the same level beneath the sea. If such structures actually represented the basis of all atolls, some of these craters would undoubtedly be upraised above the sea-level. "Nevertheless," Darwin remarks, "if the rim of a crater afforded a basis at the proper depth, I am far from denying that a reef like a perfectly characterised atoll might not be formed on it. Some such, perhaps, now exist; but it is incredible that the greater number could have thus originated."

An earlier theory, first put forward by Chamisso, concerning the origin of atolls, is next discussed. That writer suggests that, as the more massive kinds of corals prefer the surf, the outer portions of a reef will first reach the surface, and consequently form a ring. This theory is dealt with by Mr. Darwin, thus—"I have previously remarked that a reef growing on a detached bank would tend to assume an atoll-like structure; if, therefore, corals were to grow up from a bank some fathoms submerged in a deep sea, having steep sides and a

level surface, a reef not to be distinguished from an atoll might be formed; and I believe some such exist in the West Indies. But in this view it must be assumed that in every case the basis consists of a flat bank; for if it were conically formed, like a mountainous mass, we can see no reason why the corals should spring up from the flanks instead of from the central and highest parts. As the lagoons of atolls are sometimes forty fathoms deep, it must, also, be assumed, in this view, that at a depth at which the waves do not break, the coral grows more vigorously on the edges of a bank than on its central part; and this is an assumption without any evidence." The objection raised by Mr. Darwin to the foregoing theory of atoll formation, in so far as it relates to positive evidence being at that time wanting to prove "that coral grows most vigorously on the edges of a bank," is somewhat weakened by the results of investigations prosecuted and recorded since his decease. Many of the photographic reef-views in this volume, moreover, unmistakably indicate a more retarded central, and most vigorous peripheral, growth.

No special theory worthy of notice at the date of publication of Mr. Darwin's book had been brought forward to account for the presence of those barrier reefs which encircle islands of moderate dimensions. It is mentioned, however, by this authority that "the great reef which fronts the coast of Australia has been supposed, but without any evidence, to rest on the edge of a submarine precipice parallel to the shore."

Mr. Darwin's original theories concerning the origin of atolls and barrier reefs may now be submitted *in extenso*. "What cause," he writes, "then, has given to atolls and barrier reefs their characteristic form? Let us see whether an important deduction does not follow from the following facts: first, that reef-building corals only flourish at a very limited depth; and, secondly, that throughout areas of vast dimensions, none of the coral reefs and coral islets rise to a greater height above the level of the sea than that attained by matter thrown up by the wind and waves." In vindication of this last assertion the respective superficial areas of the Low, Marshall, Caroline, and Maldivas Archipelagoes, situated in the Indian and the Pacific Oceans, are described at length—no one of them contains an islet which rises above the height to which waves and wind or open sea can heap up matter. One of these areas, situated between the Low and the Marshall Archipelagoes, is shown to include a narrow band of ocean more than 4,000 miles in length and to embrace a vast number of islands, all of which present the same low character.

The argument is continued thus: "On what foundations, then, have these reefs and islets of coral been constructed? A foundation must originally have been present beneath each atoll, at that limited depth which is indispensable for the first group of the reef-building polyps. A conjecture will perhaps be hazarded, that the requisite bases may have been afforded by the accumulation of great banks of sediment which did not quite reach the surface owing to the action of superficial currents aided possibly by the undulatory movement of the sea. This

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

STAG'S-HORN REEF, OUTER BARRIER SERIES, No. 1.

appears actually to have been the case in some parts of the West Indian Sea. But in the form and disposition of the groups of atolls there is nothing to countenance this notion; and the assumption that a number of immense piles of sediment have been heaped on the floor of the great Pacific and Indian Oceans in their central parts, far remote from land, where the dark blue colour of the limpid water bespeaks its purity, cannot for one moment be admitted.*

"The many widely scattered atolls must therefore rest on rocky bases. But we cannot believe that a broad mountain summit lies buried at the depth of a few fathoms beneath every atoll, and nevertheless that throughout the immense area above named, not one point of rock projects above the level of the sea. Even if it be assumed, without any evidence, that the reef-building corals can flourish at a depth of one hundred fathoms, yet the weight of the above argument is but little diminished; for it is almost equally improbable, that as many submarine mountains as there are low islands in the several great and widely-separated areas above specified, should all rise within six hundred feet of the surface of the sea and not one above it, as that they should be of the same height within the smaller limit of one or two hundred feet. So highly improbable is this supposition, that we are compelled to believe that the rocky foundations of the many atolls were never, at any one period, all submerged within the depth of a few fathoms beneath the surface, but that they were brought into the requisite position or level, some at one period and some at another, through movements in the earth's crust. But this could not have been effected by elevation; for the belief that points so numerous and so widely separated were successively uplifted to a certain level, but that not one point was raised above that level, is quite as improbable as the former supposition, and indeed differs little from it. . . . If, then, the foundations of the many atolls were not uplifted into the requisite position, they must of necessity have subsided into it, and this at once solves every difficulty, for we may safely infer from the facts already submitted that during a gradual subsidence the corals would be favourably circumstanced for building up their solid frameworks and reaching the surface, as island after island slowly disappeared. Thus areas of immense extent in the central and most profound parts of the great oceans might become interspersed with coral islets, none of which would rise to a greater height than that attained by detritus heaped up by the sea, and nevertheless they might all have been formed by corals, which absolutely require for their growth a solid foundation within a few fathoms of the surface."

As frankly conceded by Mr. Darwin, there is very little direct evidence to prove the phenomenon of a subsiding movement throughout the areas referred to, though such testimony as is adduced points strongly in that direction. Among the facts that he cites in favour of the

* This theory, which is in direct opposition to Mr. Darwin's, is, as will be hereafter seen, that which has recently been most vigorously upheld.

subsidence theory, we select the following: "In Kotzebue's Voyage, there are accounts of islands, both in the Caroline and Marshall Archipelagoes which have been partially washed away during hurricanes. A storm lately entirely swept away two of the Caroline Islands, and converted them into shoals; it also partly destroyed two other islands. According to a tradition which was communicated to Captain Fitzroy, it is believed that the arrival of the first ship caused a great inundation which destroyed many lives. Mr. Stuchbury relates that in 1825 the western side of Chain Atoll in the same group was completely devastated by a hurricane, and not less than three hundred lives lost; in this instance it was evident, even to the natives, that the hurricane alone was not sufficient to account for the violent agitation of the ocean. With respect to Whitsunday and Gloucester Islands, in the Low Archipelago, we must either attribute great inaccuracy to their discoverer, the famous circumnavigator, Wallis, or believe that they have undergone a considerable change in the period of fifty-nine years, between his voyage and that of Captain Beechy. Whitsunday Island is described by Wallis as 'about four miles long and three wide. Now, it is only one mile and a half long. Blenheim Reef, in the Chagos group, consists of a water-washed annular reef, thirteen miles in circumference, surrounding a lagoon ten fathoms deep; on its surface there are a few worn patches of conglomerate coral-rock of about the size of hovels, and these Captain Moresby considers as being without doubt the last remnants of islets; so that here an atoll has been converted into an atoll-formed reef.* The inhabitants of the Maldiva Archipelago, as long ago as 1605, declared, 'that the high tides and violent currents were always diminishing the number of the islands.'"

Here is Mr. Darwin's summary of the whole evidence adduced:—"The facts then stand as follows: There are many large spaces of ocean, without any high lands, interspersed with reefs and islets formed by the growth of those kinds of coral which cannot live at great depths; and the existence of these reefs and low islets in such numbers and at such distant points is inexplicable, excepting on the theory that their rocky bases slowly and successively sank beneath the level of the sea, whilst the corals continued to grow upwards. No positive facts are opposed to this view, and some direct evidence, as well as general considerations, render it probable."

Mr. Darwin's very logical chain of reasoning is here supplemented by two exceedingly explicit diagrammatic illustrations, which have, from the date of their publication, been awarded a prominent position in every biological class-book. These diagrams, together with the original explanatory text, are reproduced with the courteous permission of the publishers and proprietors of the work, Messrs. Smith, Elder, & Co.

* It appears to the author just possible that these conglomerate coral-rock boulders, reported by Captain Moresby, have been detached by storm-waves from the outer edge, and thrown on the surface of the platform-reef, as in the lower of the two illustrations in Plate XXX.

ILLUSTRATING MR. CHARLES DARWIN'S THEORIES OF THE ORIGIN OF BARRIER REEFS AND OF LAGOON ISLANDS OR ATOLLS.

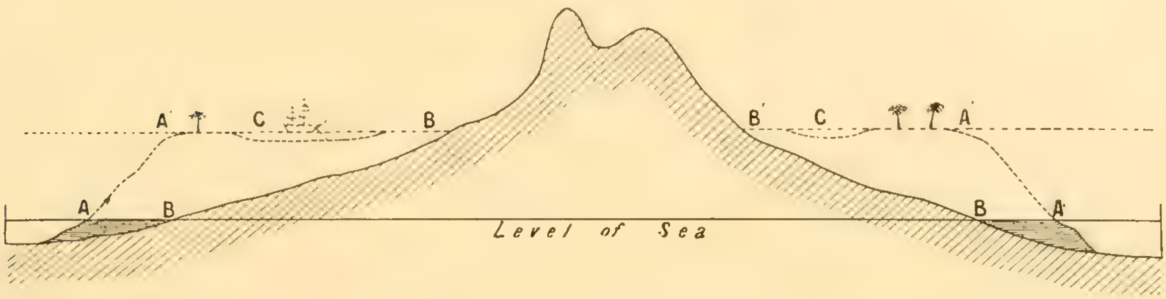


FIG. 1.—AFTER DARWIN.

AA.—Outer edge of the reef at the level of the sea.

BB.—Shores of the island.

A'A'.—Outer edge of the reef after its upward growth during a period of subsidence.

CC.—The lagoon channel between the reef and the shores of the now encircled land.

B'B'.—The shores of the encircled island.

N.B.—In this and the following woodcut, the subsidence of the land could only be represented by an apparent rise in the level of the sea.

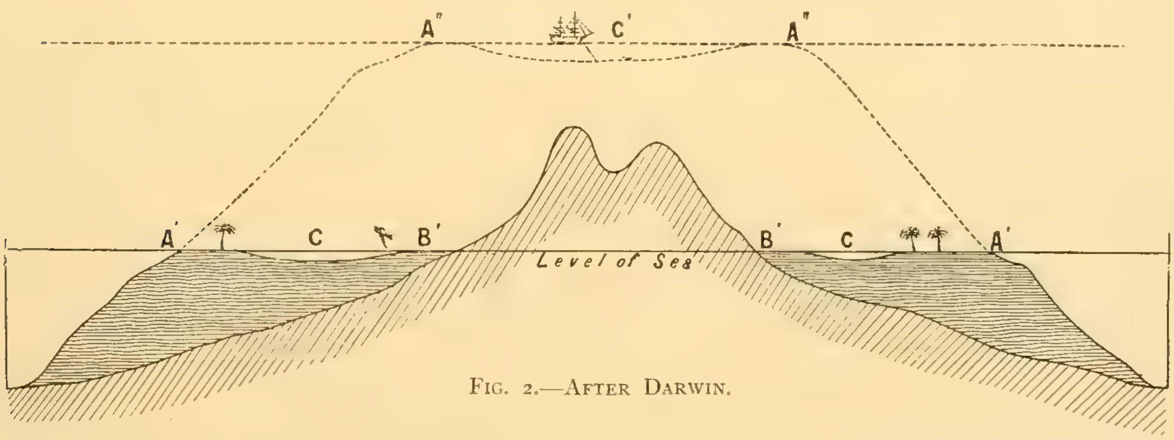


FIG. 2.—AFTER DARWIN.

A'A'.—Outer edges of the Barrier Reef at the level of the sea. The cocoanut trees thus represent coral-islets formed on the reef.

CC.—The lagoon channel.

B'B'.—The shores of the island, generally formed of low alluvial land, and of coral detritus from the lagoon channel.

A"A".—The outer edges of the reef, now forming an atoll.

C'.—The lagoon of the newly-formed atoll. According to the scale the depth of the lagoon and of the lagoon-channel is exaggerated.

The explanation of Mr. Darwin's diagrams is as follows:—

"Let us in imagination place within a subsiding area an island surrounded by a fringing

reef—that kind of which the origin alone offers no difficulty. Let the unbroken lines on the diagram (No. 1) represent a vertical section through the land and water, and the horizontal (darkest) shading a section through the reef. Now as the island sinks down, either a few feet at a time or quite insensibly, we may infer, from what we know of the conditions favourable to the growth of coral, that the living masses bathed by the surf on the margin of the reef will soon regain the surface. The water, however, will encroach little by little on the shore, the island becoming lower and smaller, and the space between the edge of the reef and the beach proportionately broader. A section of the reef and island in this state after a subsidence of several hundred feet is given by the dotted lines. Coral islets are supposed to have been formed on the new reef, and a ship is anchored in the lagoon channel. This section is, in every respect, that of an encircling barrier reef, and is, in fact, taken E. and W. through the highest point of the encircled island of Bolabola. The same section is more clearly shown in the following woodcut (No. 2) by the unbroken lines. The width of the reef and its slope, both on the outer and inner side, will have been determined by the growing powers of the coral, under different conditions, for instance, of the force of the breakers and currents to which it has been exposed; and the lagoon-channel will be deeper or shallower, in proportion to the growth of the delicately branched corals within the reef and to the accumulation of sediment; relatively, also, to the rate of subsidence, and the length of the intervening stationary periods.

"It is evident in this section that a line drawn perpendicularly down from the outer edge of the new reef to the foundation of solid rock, exceeds, by as many feet as there have been feet of subsidence, that small limit of depth at which the effective polypipes can live—the corals having grown up as the whole sank down from a basis formed of other corals and their consolidated fragments. Thus the difficulty on this head, which before seemed so great, disappears.

"As the space between the reef and the subsiding shore continued to increase in breadth and depth, and as the injurious effects of the sediment and fresh water borne down from the land were consequently lessened, the greater number of the channels with which the reef in its fringing state must have been breached, especially those which fronted the smaller streams, will have become choked up by the growth of coral; on the windward side of the reef, where the coral grows most vigorously, the breaches will probably have first been closed. In barrier reefs, therefore, the breaches kept open by draining the tidal waters of the lagoon-channel, will generally be placed on the leeward side, and they will still face the mouths of the larger streams, although removed beyond the influence of their sediments and fresh water; and this, it has been shown, is commonly the case.

"Referring to the following diagram (No. 2 A), in which the newly-formed barrier reef is represented by unbroken lines, instead of by dots, as in the former woodcut, let the work

of subsidence go on, and the doubly pointed hill will form two small islands included within one annular reef. Let the island continue to subside, and the coral-reef will continue growing up on its own foundation, whilst the water gains inch by inch on the land until the last and highest pinnacle is covered, and there remains a perfect atoll. A vertical section of this atoll is shown in the woodcut by the dotted lines: a ship is anchored in its lagoon, but islets are not supposed yet to have been formed on the reef. The depths of the lagoon and the width and slope of the reef will depend on the different circumstances to which it has been exposed, as just stated with respect to barrier reefs. Any further subsidence will produce no change in the atoll except a diminution in its size from the reef not growing vertically upwards. I may here observe that a bank, either of rock or of hardened sediment, level with the surface of the sea and fringed with living coral, would be immediately converted by subsidence with an atoll, without passing, as is the case of a reef fringing the shore of an island, through the intermediate form of a barrier reef. As before remarked, if such a bank lay a few fathoms submerged the simple growth of the coral, without the aid of subsidence, would produce a structure scarcely to be distinguished from a true atoll; for the corals on the outer margin, from being freely exposed to the open sea, would grow vigorously, and tend to form a continuous ring, whilst the growth of the less massive kinds in the central expanse would be checked by the sediment formed there, and by that washed inwards by the breakers; and, as the space became shallower, their growth would also be checked by the impurities of the water, and probably by the small amount of food brought to them by the enfeebled currents. The subsidence of a reef based on a bank of this kind would give depth to the central expanse or lagoon, steepness to the flanks, and, through the free growth of the coral, symmetry to the whole outline; but, as we have seen, the larger groups of atolls in the Pacific and Indian Oceans cannot have been formed on banks of this nature."

"If, instead of an island, as in the diagrams, the shore of a continent fringed by a reef were to subside, a great barrier reef, like that on the N.E. coast of Australia, would be the necessary result; and it would be separated from the mainland by a deep-water channel, broad in proportion to the amount of subsidence, and to the less or greater inclination of the bed of the sea."

What the Great Barrier Reef of Australia has to say in support of the deduction implied in the foregoing paragraph we shall see a little later. The reader should now be in a position to comprehend and appreciate the highly logical and sagacious line of reasoning brought to bear by the illustrious naturalist, on the interpretation of this exceedingly difficult subject, and to apprehend the cogency of the evidence, for and against it, that has been brought forward by later observers. As the phenomenon of geological subsidence is necessarily bound up with this Darwinian theory of the primary origin of atolls and barrier-reefs,

it is generally distinguished by the title of the "subsidence theory," and as such is hereafter referred to.

Among the more eminent authorities on the subject of coral-reefs, who have been afforded an opportunity of putting Mr. Darwin's theory partly to the test, mention must be made of James D. Dana, Professor of Geology and Minerology in Yale College, U.S.A. His name will ever be associated with one of the finest illustrated works on the subject of corals and coral-animals such being the nature of his magnificent folio Report on the Zoophytes of the *Wilkes*' U.S. Exploring Expedition, published by the United States Government. This expedition, to which Professor Dana was attached as zoologist and geologist, was conducted between the years 1838 and 1842, and covered much of the ground previously visited by Mr. Darwin. A compendious *résumé* of all the leading features of the larger work, together with a masterly account of subsequently-acquired data, bearing on the same subject, is embodied in the smaller work, entitled "Corals and Coral Islands," published by the same author in the year 1872. Professor Dana's thoughts on Darwin's subsidence theory may be cited in his own words from the last-named work.—

"Our cruise led us partly along the course followed by Mr. Charles Darwin during the years 1831 to 1836, in the voyage of the *Beagle*, under Captain Fitzroy; and, where it diverged from his route, it took us over scenes, similar to his, of coral and volcanic islands. Soon after reaching Sydney, Australia, in 1839, a brief statement was found in the papers of Mr. Darwin's theory with respect to the origin of the atoll and barrier forms of reefs. The paragraph threw a flood of light over the subject, and called forth feelings of peculiar satisfaction, and of gratefulness to Mr. Darwin, which still come up afresh whenever the subject of coral islands is mentioned. The Gambier Islands, in the Paumotus, which gave him the key to the theory, I had not seen; but on reaching the Fijis, six months later, in 1840, I found there similar facts on a still grander scale and of more diversified character, so that I was afterwards enabled to speak of his theory as established with more positiveness than he himself, in his philosophic caution, had been ready to adopt."

In his general summary of the abundant evidence he adduces in support of the subsidence theory, as applied to the coral-reef area he personally investigated, Professor Dana sums up as follows:—

"*What is the extent of the subsidence indicated by the coral-reefs and islands of the Pacific?* It is very evident that the sinking of the Society, Samoan, and Hawaian Islands has been small compared with that required to submerge all the lands on which the Paumotus and the other Pacific atolls rest. One, two, or five hundred feet could not have buried the many peaks of these Islands. Even the 1,200 ft. of depression at the Gambier group is shown to be at a distance from the axis of the subsiding area. The groups of high islands, above mentioned, contain summits from 4,000 to 14,000 feet above the sea, and can we believe it possible that throughout this large area, when the two hundred islands now sunken were above the waves, there were none of them equal in altitude to the mean of these heights, or 9,000 feet? That none should have exceeded 9,000 feet in elevation is by no means probable. Hence, however moderate the

estimate, there must still be allowed a sinking of many thousand feet. Moreover, whatever estimate we make that is within probable bounds, we shall not arrive at a more surprising change of level than our continents show that they have undergone ; for since the Tertiary began (or the preceding period, the Cretaceous, closed), more than 10,000 feet have been added to the Rocky Mountains, and parts of the Andes, Alps, and Himalayas.

"Between the New Hebrides and Australia, the reef and islands mark out another depression, which may have been simultaneously in progress. The long reef of one hundred and fifty miles from the North cape of New Caledonia, and the wide barrier on the west, cannot be explained without supposing a subsidence of one or two thousand feet at the least. The distant barrier of Australia is proof of great subsidence even along the border of that continent. But the greatest amount of sinking took place, in all probability, over the intermediate sea called the 'Coral Sea,' where there is now a considerable number of atolls."

The testimony and the conclusions elicited and adduced by J. B. Jukes, in his narrative of the surveying voyage of H.M.S. *Fly*, conducted during the years 1842 and 1846, might be advantageously introduced at this point. Since, however, the evidence in question bears almost exclusively upon the phenomena associated with the Australian Barrier region, it may be more appropriately reserved for consideration when dealing with this specially defined area.

Evidence has now to be submitted in the order of its chronological incidence, that has the avowed object of demonstrating that Mr. Darwin's subsidence theory cannot be accepted as explaining the normal conditions under which atolls and barrier-reefs are constructed. In fair justice to the originator of, and the participators in this newer "anti-subsidence" theory, it is incumbent that an equal space should be given to the exposition of their views.

Foremost in the ranks of the several authorities who, on the strength of the further information accumulated within the last two decades, have been unable to accept Mr. Darwin's interpretations, must be mentioned Dr. John Murray, a member of the scientific staff of the *Challenger* Exploring Expedition, and consequently qualified by a varied acquaintance with corals and coral-reefs to speak from practical experience on this intricate subject. The fullest exposition of Dr. Murray's newer views, embodying his indictment of the subsidence theory, is contained in a paper communicated to the Proceedings of the Royal Society of Edinburgh, Vol X., 1880, and in a lecture on the "Structure, Origin, and Distribution of Coral Reefs," delivered by him at the Royal Institution, March 14, 1888. So excellent an abstract of Dr. Murray's essays appears in Dr. J. G. Bonny's appendix to the latest 1889 edition of Mr. Darwin's treatise that it is herewith reproduced *verbatim*. To prepare the reader for the new line of argument taken up by this authority, a brief sentence is culled, by way of introduction, from Dr. Murray's London Institution thesis. It begins as follows :—"It seems impossible, with our present knowledge, to admit that atolls or barrier-reefs have *ever* been developed after the manner indicated by Mr. Darwin." The one word italicised in the foregoing sentence has been purposely annotated by the author: with the object of emphasising

the totally uncompromising attitude towards the subsidence theory that is assumed by Dr. Murray.

The detailed exposition of Dr. Murray's views as epitomised by Dr. Bonny is herewith submitted :—

"Very nearly all oceanic islands, other than coral atolls, are now known to be of volcanic origin. Hence it is probable that the foundations of the latter are volcanic rocks, and not those of an ancient pre-existent land. As shown by the soundings of the *Tuscarora* and *Challenger*, numerous submarine elevations exist which rise from depths of 2,000 to 3,000 fathoms to within a few hundred fathoms of the surface. The upper waters of the ocean (to a depth probably of about 100 fathoms) teem with organisms, calcareous and siliceous, such as algæ, protozoa, hydrozoa, mollusca, and other members of the animal kingdom : these are drifted by the currents from place to place ; by these the reef-building corals are supplied with food. It has been estimated as the result of experiment, that a mass of ocean water one mile square and 100 fathoms deep, contains more than sixteen tons of carbonate of lime. After death the skeletons of these organisms are showered down upon the bed of the ocean. In water which exceeds some 800 or 900 fathoms in depth these remains are more or less affected by the solvent power of the carbonic acid present in the water, but at less depth they accumulate. Thus, any submarine bank which rose within the above-named depth would be brought nearer to the surface, and its upper part, as the water above it shallowed, would be colonised by larger pelagic organisms, these after death would augment by their remains the increasing pile of material, which at last would arrive within the bathymetrical zone in which the reef-building corals can live, and the formation of an atoll would commence.

"As already pointed out by Mr. Darwin, the corals on the outer margin of a bank grow vigorously, while the diminution of food and the increase of sediment tend to check the development of those in the inner part. Thus, while the reef is still several fathoms below the surface, the corals in the central part are placed at a disadvantage, which becomes greater as they are left behind in the upward race by their neighbours. In a small reef, the periphery for the supply of food to the interior is relatively large, thus the lagoons in small atolls are also small and soon filled up, while long and narrow banks have no lagoons. As the reef becomes larger the conditions become more favourable to the formation of lagoons, for (as is shown by experiment) the lagoon of such an atoll is less rich in pelagic life than the exterior water. Thus growth is checked, many species of coral die, and their calcareous 'skeletons' are exposed to the solvent action of sea-water. When the water outside becomes too deep for reef-building corals to live, the *débris* from the existing reef, aided by the accumulation of organisms, forms a talus at the foot of its submarine cliffs, and thus the reef spreads slowly outwards, 'like a fairy ring,' on foundations to which its own materials have contributed. The lagoon-channels have in many cases been subsequently formed by the solvent action of sea-water, and the islets in the lagoon-channels are parts of the original reef still left standing. When the reefs rise quite up to the surface and are nearly continuous, there is little coral-growth in the lagoon or its channels ; where the outer reefs are much broken up, the growth is relatively abundant.

"At the Admiralty Islands, on the lagoon side of the islets of the barrier reefs, the trees are found overhanging the water, and in some cases the soil was washed away from their roots. It is a common observation in atolls that the islets on the reefs are situated close to the lagoon shore. These facts point out the removal of matter which is going on in the lagoons and lagoon-channels.

"Elevation, not subsidence, is to be expected in a volcanic region, as there is an *à priori* reason for attributing the phenomena of coral reefs—as resting on volcanic foundations—to elevation rather than subsidence. The former hypothesis appears to Mr. Murray to accord with all the facts indicated by the published charts of coral-reefs, and thus is considered by him preferable to the latter."

Mr. Murray's general conclusions may be briefly enumerated as follows :—

A. LOW WOODY REEF, OUTER BARRIER SERIES, No. 2.

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

B. LOW WOODY REEF, OUTER BARRIER SERIES, No 3.

"1. That foundations have been prepared for barrier reefs and atolls by the disintegration of volcanic islands, and by the building up of submarine volcanoes, and by the deposition on their summits of organic and other sediments.

"2. That the chief food of the corals consists of the abundant pelagic life of the tropical regions, and the extensive solvent action of sea water is shown by the removal of the carbonate of lime shells of these surface organisms from the greater depths of the ocean.

"3. That when coral plantations build up from submarine banks they assume an atoll form, owing to the more abundant supply of food to the outer margins, and the removal of dead coral-rock from the interior portions by currents and the action of the carbonic acid dissolved in the water.

"4. That barrier reefs have built out from the shore on a foundation of volcanic *débris*, or on a talus of coral-blocks, coral sediment, and pelagic shells, and the lagoon-channel is formed in the same way as a lagoon.

"5. That it is not necessary to call in subsidence to explain any of the characteristic features of barrier reefs or atolls, and that all their features would exist alike in areas of slow elevation, of rest, or of slow subsidence."

The next instalment of evidence, following that of Dr. Murray, evidence which gives the last-named authority's new theory substantial support, is contributed by Mr. H. B. Guppy with relation to the coral formations of the Solomon Islands. This area, having been the scene within post-Tertiary times of volcanic upheaval, estimated at not less than 12,000 feet, has revealed at the hands of Mr. Guppy some important testimony concerning the thickness of the upheaved coral-reefs, and the nature of their formation. Mr. Guppy's original report on the coral-reefs of this region appears in the "Proceedings of the Royal Society of Edinburgh" for the years 1885-6, while the geological bearings are more exhaustively dealt with in a special volume, "The Solomon Islands: Their Geology," &c., published in the year 1887. The analysis of Mr. Guppy's evidence, embodied in Professor Bonny's appendix to the third edition of Mr. Darwin's "Structure and Distribution of Coral-Reefs," is freely quoted.—

"Mr. Guppy describes the Solomon Archipelago, which includes seven or eight large islands, some being from seventy to eighty miles in length, and the highest rising from 8,000 to 10,000 feet above the sea, with a great number of smaller islands and islets, some of volcanic and others of recent calcareous formations.

"The islands examined indicate upheaval in some cases to at least 12,000 feet. [Direct testimony to this effect is yielded, in Mr. Guppy's opinion, by the fact that deep-sea deposits, which have been formed in depths probably of from 1,000 to 2,000 fathoms, were found to compose the summit of Treasury Island, 1,150 feet above the sea, and apparently also formed the capping investment of a portion of Choiseul Island at the still higher elevation of 1,500 feet and over.] There are in the first place numerous small islands and islets, less than a hundred feet in height, which are composed entirely of coral limestone. Then there are islands of larger size, which are composed in bulk of partially consolidated volcanic muds, such as are at present forming around oceanic volcanic islands. Coral limestones encrust the lower slopes of these islands, and do not attain a greater thickness than 150 feet. In the next place we have islands of similar structure, but possessing in their centre some ancient volcanic peak that was once submerged. Then there are islands in which the volcanic peak has become an eccentric nucleus, from which line after line of barrier reef has been advanced, overlying the volcanic muds—islands in which he did not find the coral limestone of a thickness of 100 feet. Then we have the upraised atoll, such as Santa Anna, which, within the small compass of a height of 470 feet, displays the several stages of its growth; first, the originally submerged volcanic peak, then the investing soft deposit, and over all the ring of coral limestone, that cannot far exceed 150 feet in thickness; lastly, we come to the mountainous islands formed of old volcanic

rocks, such as St. Christoval, which, although over 4,000 feet in height, showed no calcareous envelopes of a greater height than 500 feet above the sea, the coral limestone crust being even thinner than at the smaller and more recent islands. From these considerations Mr. Guppy concludes (1) that these upraised reef-masses, whether atoll, barrier reef, or fringing-reef, were formed in a region of elevation; (2) that such upraised reefs are of moderate thickness, their virtual measurement not exceeding the limit of the depth of the coral-reef zone—*i.e.*, not more than about 150 feet; (3) that these upraised reef-masses in the majority of islands rest on a partially consolidated deposit which possesses the characters of the 'volcanic muds,' which were found during the *Challenger* expedition to be at present forming around volcanic islands; (4) that this deposit envelops anciently submerged volcanic peaks."

An important communication bearing on Dr. Murray's new theory of atoll and barrier-reef formation is contributed by Captain Wharton, R.N., Hydrographer to the Admiralty, to the columns of *Nature* of Feb. 23, 1888. The article supports Mr. Murray's views in as far as it expresses the writer's opinion that the later evidence on coral growth justifies an abandonment of the supposition that subsidence plays a principal part in the production of barrier reefs and atolls; but, at the same time, it opposes Dr. Murray's theory that the disintegration and solution of dead coral by the chemical action of sea-water is a primary factor in the hollowing and deepening of the lagoons that characterised the interiors of both these classes of reefs. The Tizard and Macclesfield Banks in the China seas are specially adduced in this association. Respecting the former, Captain Wharton writes: "The Tizard Bank, in lat. 10° 20″ N., and long. 114° 25″ E., is thirty-two nautical miles in length with an extreme breadth of ten miles, and was well surveyed in 1867. The central portion is very flat and almost void of patches. Its depth is from thirty to forty-seven fathoms. Its edge is crowned with a coral rim varying from four to ten fathoms in depth, broken here and there by openings, in some cases over thirty fathoms deep. The rim is composed of coral in luxuriant growth, and it can scarcely be doubted that in time it will reach the surface. In fact, on its periphery of 100 miles, in eight places small patches of reef, three of which bear islets, have already done so. When the remaining portions of the rim are also awash, the reef will be in all respects an atoll similar to the great Madive atolls, without any necessity for solvent action enlarging or deepening it.

"The great Macclesfield Bank, further north, over seventy miles in length and forty miles in width, is of precisely the same nature, but its development is not so far advanced; the rim being in no spot nearer the surface than ten fathoms, the water on it varying from that amount to nineteen fathoms, while the depth of the enclosed area is from forty to sixty fathoms. The survey of this bank is not so complete as in the case of some others, but enough has been done to show its character very plainly.

"How, precisely, it comes about that coral is growing in the yet deep rims of these large banks and that little or none is flourishing in the interior, evidence is yet wanting to show. These, however, are the facts, and the result, so far as the necessity for further

scooping out is concerned, seems indisputable. I may, nevertheless, offer a suggestion: This condition of reef is apparently only to be accounted for in two ways—either by subsidence, or by assuming that the animals, be they corals or other lime-secreting organisms that settle on the bank, do, when it gets, by their accumulation, within a certain distance of the surface, and under certain conditions of current and food supply, intercept so much of the food borne in by the currents, that similar life, suitable to that depth zone, cannot be supported in the central area. Thenceforward, the rim alone will grow, and the organisms fitted to live in the successively shallower zones to the surface will alone find foothold on it. This would be the perfect atoll, but, with less nicely-balanced conditions, growth would also take place in patches in the central area, as is often the case."

The foregoing evidence by Captain Wharton concerning the Tizard and Macclesfield can be scarcely said to invalidate Mr. Darwin's subsidence theory, since it is frankly admitted that the existing condition of their associated reefs may be, alternatively, accounted for by subsidence.

Testimony of a similar somewhat negative description regarding the subsidence theory, and in direct opposition to Dr. Murray's chemical-solution interpretation, was adduced about the same time by Mr. G. C. Bourne, in the form of a paper printed in the "Proceedings of the Royal Society," Vol. XLIII., 1888, dealing with the coral atoll of Diego Garcia, and other coral-reef formations of the Chagos Archipelago. Here, again, it has been found most desirable to submit a *précis* of Dr. Bonney's longer abstract published in Appendix II. of the third edition of Mr. Darwin's treatise.—

"Mr. G. C. Bourne gives a minute description of the atoll of Diego Garcia, and discusses the theories of coral-reef formation in connection with the Chagos group. In the Laccadive, Maldive, and Chagos group, there is no instance of a fringing or a barrier reef; nothing but coral structures rise above the waves; and all the islands are atolls. The three groups are believed to stand on a submarine bank lying 1,000 feet below the surface in an ocean of an average depth of 2,000 fathoms. At Diego Garcia, the shores externally slope away very rapidly to considerable depths, the sounding line giving depths 250 fathoms and upwards at a distance of a few hundred yards from the edge of the reef, except in one case. The depths inside the lagoon vary up to nineteen fathoms. Mr. Bourne describes the different kinds of coral-rocks, and gives reasons for supposing that there has been a recent elevation of a few feet. He calls attention to the changes produced by the action of the waves and currents, and to the effect of the latter upon the growth of the coral: showing how the living coral may be killed by a change in a current which, formerly clear, now brings sand. This material proceeds to entomb the dead coral, and then, on a return to the former conditions, a new growth of coral may take place upon a stratum of sand. He is of opinion that the subsidence theory cannot be applied to explain the Great Chagos Bank, because its rim is on an average not more than six fathoms below the surface, and therefore situated in a depth eminently favourable for coral growth, and there are actually six islets on the northern and western edges rising above the water, and some of them inhabited! He indicates further difficulties in applying the theory of subsidence to the Chagos Bank, especially pointing out that the six-island atoll, within a few miles' distance, has not been affected; still, he admits that the Saya de Malha Bank appears to have the character of a submerged atoll, having a central depression of sixty-five fathoms, surrounded by a rim which has only eight to sixteen fathoms on its eastern side, but twenty-two fathoms on the

western. [On the whole, however, he considers that most of the coral formations of the Indian Ocean mark areas of elevation rather than of rest or subsidence.]

"In regard to the explanations of the formation of lagoons by solution of the interior parts of the reef, and by the more rapid growth of the corals on its periphery, as being more directly in the track of food-bearing currents, Mr. Bourne observes:—'Neither of these explanations has completely satisfied me. That sea-water exercises a solvent action upon carbonate of lime does not admit of doubt, and that the scour of tides, combined with this solvent action of the water, does affect the extent and depth of a lagoon, is obvious. But I challenge the statement that the destructive agencies within an atoll or a submerged bank, are in excess of the constructive. It would be nearer the mark to say that they nearly balanced one another. In the first place the carbonate of lime held in solution by sea-water is deposited as crystalline limestone in the interstices of dead corals or coral *débris*. Anyone who is acquainted with the structure of coralline rock knows how such a porous mass as a Mæandrina head becomes perfectly solid by the deposition of lime within its mass. This deposition can only be effected by the infiltration of sea-water. In reckoning the solvent action of sea-water, therefore, account must be taken of the fact that a not inconsiderable proportion of the carbonate of lime held in solution is re-deposited in the form of crystallised limestone. Of this it seems Mr. Murray has not taken sufficient account, and has therefore overstated the destructive agency of the sea. Secondly, the growth of corals and the consequent formation of coral-rock within the lagoon is generally overlooked.

"'Whilst diving for corals at Diego Garcia, I had abundant opportunities of studying the formation of coral-rock within the lagoon, in depths under two fathoms. The layers of tolerably compact rock thus formed are of no mean extent or thickness, they soon become covered with sand, and are thus protected from the solvent action of the water. I have found it impossible to reconcile Mr. Murray's views with what I saw of coral-growth within a lagoon. Not only do the more delicate branching species of the Madreporaria flourish in considerable numbers, but the true reef-building species, Porites, Mæandrina, Pocillopora, and various stout species of Madrepora are found there. It is a mistake to suppose that certain species of corals are restricted to the external shores, others to the lagoon. My collections proved that many of the species growing in the lagoon at distances of five miles and upwards from its outlet are identical with those growing on the outer reef. In addition to them are numerous species, such as *Seriatopora stricta*, *Mussa corymbosa*, *Favia lobata*, *Fungia dentata*, and many others are not found on the outside. The reason is that the last-named are either free forms, such as Fungia, or are attached by such slender and fragile stems to their supports that they could not possibly obtain a foothold and maintain themselves among the powerful currents and waves of the open ocean.

"'These various species, numbers of which grow close together, form knolls and patches within the lagoon, and it cannot be doubted that their tendency is to fill it up. Again, in reefs which do not rise above the surface, or are awash for the greater part of their extent at low tides, great quantities of *débris*, torn from the outer slopes, are constantly carried over the rim of the reef, and tend to fill it up. Hence it follows that in a lagoon entirely surrounded by dry land or nearly so, as is the case at Diego Garcia, the tendency to accumulation of material within the lagoon would be less than in submerged or incomplete atolls, for *débris* cannot be swept over the lagoon, and the only constructive agency is the growth of coral. If the power of solution of sea-water is so great, it must be supposed that in complete or nearly complete atolls the lagoon would be deepening rather than shallowing, yet at Diego Garcia it is obviously shallowing in many places, and has nowhere increased in depth since Captain Moresby's survey in 1837. Indeed, the southern part seems to have shoaled a fathom since that time, and this is the more remarkable since the south-east trade winds are by far the most constant and strongest winds there, and tend to accumulate material at the northern rather than the southern end. The fact is that these winds sweep the

sand out of the southern part, and thus leave an area particularly favourably situated for the growth of corals. Mr. Murray points out that larger atolls generally have deeper lagoons than small atolls, and urges this fact in support of his theory; but here again the facts in the Chagos group are against him. Victory Bank is a submerged atoll; the Solomons is an atoll with a large extent of dry land. In each the lagoon attains a depth of seventeen—eighteen fathoms, and in Diego Garcia the lagoon, although far larger, does not attain a greater depth. Peros Bauhos is far smaller than the Great Chagos Bank, yet in both the lagoons attain nearly the same maximum depth, viz., forty-one fathoms for Peros Bauhos, forty-four fathoms for the Great Chagos Bank. Speaker's Bank is very little larger than Peros Bauhos; its lagoon is far shallower, having a maximum depth of twenty-four fathoms.'"

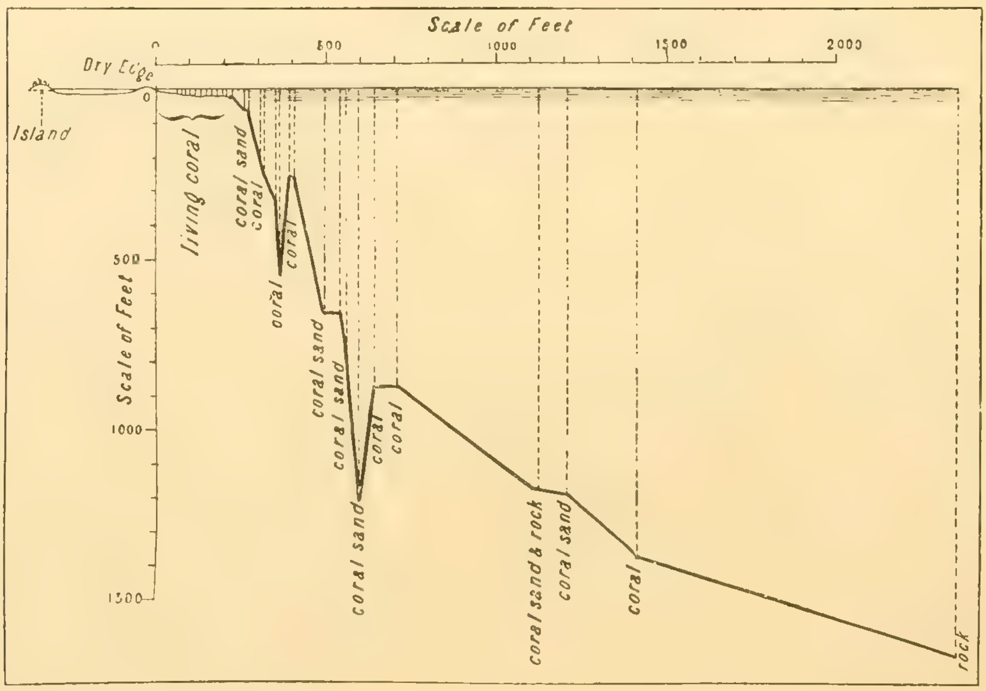
By way of placing on record some of the testimony in direct support of Mr. Darwin's subsidence theory, which was brought forward in response to the interpretation advocated by Dr. Murray, a short extract may be made from a paper contributed by Professor J. D. Dana, "On the Origin of Coral-Reefs and Islands," to the *American Journal of Science* for the year 1885.—

In this communication Professor Dana "calls special attention to the eastern half of the Fiji Archipelago where several of the great barrier-reefs from ten to twenty miles long have but one or two emergent peaks of land; Nanuku, for instance, has one little point near its south-eastern angle, a mile of peak within a barrier island, 200 square miles in area. Bacon's Isles are the last two little peaks of a still greater lagoon. . . . A dozen of the easternmost islands are actually atolls—the last peak is gone. But in case it should be answered that these are the emergent portions of submarine volcanoes, in which case the ring-shaped barriers become difficult of explanation, while they are easy on the theory of subsidence, Professor Dana adds, that movement in this direction is proved by the existence of deep fiord-like indentations in rocky coasts of islands, both of those inside of barriers, and those not bordered by reefs. As examples of this structure, generally admitted to be one of the strongest evidences of subsidence all the world over, he quotes the Marquesas Islands with the Gambier and the Hogoleu Islands, Raiata, Bolabola, and the Tahiti group, and the Exploring Isles of the Fijis. Professor Dana also calls attention to the general parallelism between the average trends of coral islands and the courses, not only of the groups of which they form part, but also of the groups of high islands, not far distant, and refers to the arguments drawn by Mr. Darwin from the fact that the larger coral islands have the same diversity of form as is found in the barrier-reefs of high islands, and exhibit grouping such as would result from the sinking of a large island of ridges and peaks with encircling reefs. The depth of the lagoon, and of the channels inside of barrier-reefs—in many cases two or three times greater than twenty fathoms—is very difficult to explain if there has been no subsidence, so is that of the ocean near to atolls."

Among the more important evidence, recently adduced, that gives direct support to Mr. Darwin's subsidence interpretation of barrier and atoll-reef construction, reference may be made to a second communication contributed by Captain Wharton, R.N., to *Nature*, Vol. XXXVI., p. 413. This communication referred to a recent survey made by Captain Maclear, R.N., in H.M.S. *Flying Fish*, of the small island of Masamarhu, in the Red Sea, and embodies two sections, true to scale, of the coral-reefs that surround it. These sections, through the kind courtesy of the publishers, Messrs. Macmillan & Co., are herewith reproduced, together with the explanatory description of them given in Professor Bonney's appendix to Mr. Darwin's work.—

"It is observed that there is a reasonable and significant correspondence between these two sections, which as the plan indicates, are taken nearly half-a-mile apart. In each, the surface of the fringing-reef, after shelving very gently downwards to a depth of about three or four fathoms, is bounded by a submarine cliff. This in one section (No. I.) continues almost unbroken to a depth of about 500 feet, except that a kind of edge or terrace is clearly indicated at a depth of rather less than 100 feet. In the other section (No. II.) the foot of a great submarine cliff is found at about 500 feet, but in this case the cliff is distinctly divided into two precipices by a shelving bank of coral and sand, which begins at a depth of about 140 feet and reaches the brow of the lower precipice at about 260 feet. This bank is covered by 'sand and coral.' At this depth

No. I.



in each section the island is, as it were, defended by a deep and narrow ditch, the edge of its steep glacis being formed by a sharp *arête* of coral which in one case rises into soundings of about 250 feet. From this the former section shows a second rapid fall down to another ditch, the bottom of which lies more than 1,200 feet below sea level. This in section resembles the other one, and the height of its counterscarp is more than 300 feet. From the edge of this, the glacis for a short distance is nearly level, and then descends at an angle of some thirty degrees. In the lower diagram we find no indication of this second ditch, but a long slope begins at the foot of the submarine cliff at a depth of about 850 feet, which is very nearly identical with that of the flat part of the glacis in the former section.

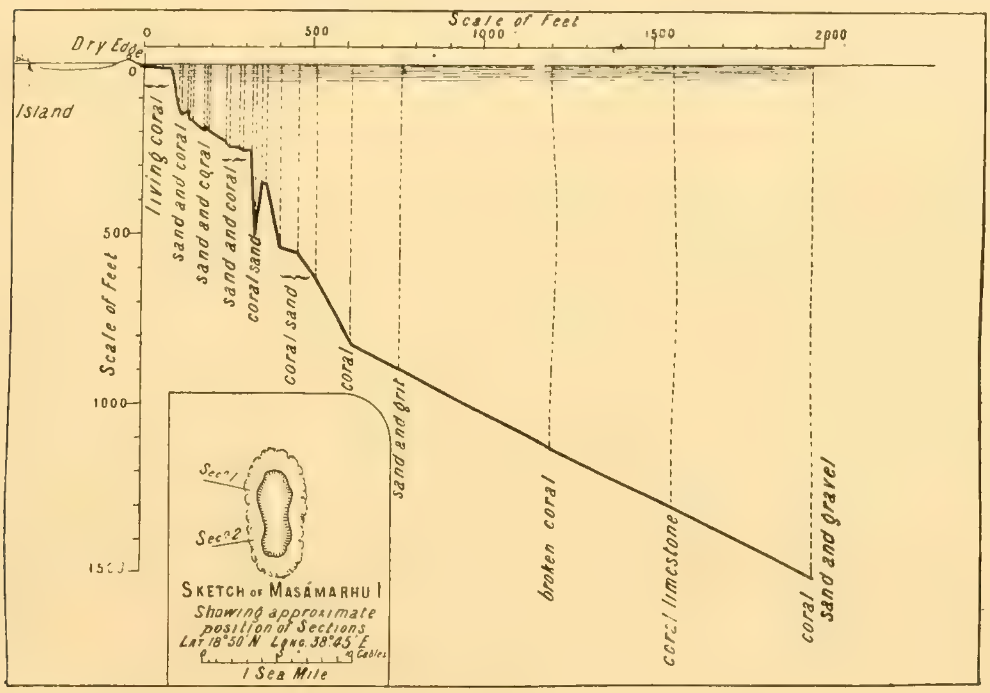
"It will be observed that the upper ditch (that common to both sections) has its bottom at a depth of full 500 feet, or about 85 fathoms—that is, at more than three times the average depth at which reef-building corals cease to live, while the least depth of the final submarine slope is 850 feet or more than 140 fathoms. These ditches seem irreconcilable with any idea of an outward-spreading growth of the reef, and must, I think, be indicative of a subsidence which isolated the outward and more flourishing edge of a shore reef, and progressed

rather too rapidly to allow its corals to extend across the trench thus formed and effect a union with the main mass. Of course, if a fissure-like hollow were once established between two masses of growing coral in a subsiding area, it would not be readily filled up, unless the edge of its outer wall were sufficiently near the surface to suffer much from the violence of the waves.

"The former section seems to me to be inexplicable under the conditions ordinarily admitted for coral growth, unless we suppose that the bottom of the lower ditch, now at a depth of over 1200 feet (200 fathoms), was formerly situated within about twenty-five fathoms of the surface; so that a subsidence of more than 1000 feet may fairly be claimed for the coral reef of Masámarhu."

As a final extract from the testimony in favour of the subsidence theory, adduced in Professor Bonney's "Appendix," already so extensively quoted, we reproduce the highly interesting results

No. II.



of some deep borings recently carried out near Honolulu, the chief town of Oahu, in the Sandwich Islands. The data here submitted were originally contributed by Professor Dana to the *American Journal of Science*, Vol. XXXVII., 1889. They indicate beyond question a very considerable amount of subsidence in the region referred to, the depth at which the "hard coral-rock," or reef-conglomerate, runs, being in all instances considerably below the plane at which it could have been originally formed.

The details of the composition of the strata perforated, given in Professor Dana's report, are as follow:—

I.—JAMES CAMPBELL'S WELL AT WEST FOOT OF DIAMOND HEAD, NOT FAR FROM SEA-LEVEL.

	Thickness (feet).	Depth (feet).
Gravel and beach sand	50	—
Tufa like that of Diamond Head	270	320
Hard coral rock, like marble	505	825
Dark brown clay	75	900
Washed gravel	25	925
Deep red clay	95	1,020
Soft white coral	28	1,048
Soap-stone-like rock	20	1,068
Brown clay and *broken coral* ...	110	1,178
Hard blue lava	45	1,223
Black and red clay	28	1,251
Brown lava	249	1,500

II.—KING'S WELL, NO. 2, ABOUT HALF A MILE WEST OF DIAMOND HILL, AND 350 YARDS FROM THE SEA-SHORE.

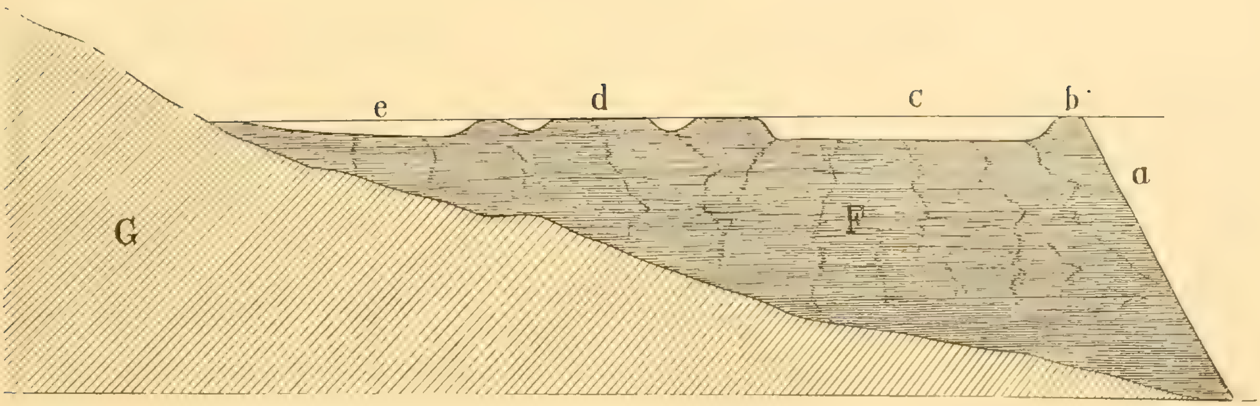
	Thickness (feet).	Depth (feet).
Sand and coral	38	—
White coral rock	22	60
Yellow sand	43	103
Hard lava	47	150
White coral rock	110	260
Blue clay	25	285
Tough clay and *coral*	65	350
Blue clay	30	380
Hard coral rock	40	420
Soft coral	30	450
Tough clay	5	455
White coral rock	40	495
Tough clay	30	525
White coral rock	100	625
Tough clay	5	630
Coral and clay	70	700
Tough clay	28	728
Black sand	2	730
Lava	120	850

III.—WELL IN THOMAS SQUARE, HONOLULU.

	Thickness (feet).	Depth (feet).
Soil 6 feet, with 6 feet of black sand, and clay 4 feet	16	—
White coral rock	200	216
Brown clay	44	260
Coral rock	10	270
Brown clay	60	330
White coral rock	50	380
Brown clay	80	460
Bed rock or lava, penetrated ...	49	509

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

SKULL REEF, OUTER BARRIER SERIES, No. 6.



HYPOTHETIC SECTION OF THE GREAT BARRIER REEF, AFTER J. B. JUKES.

a. Sea outside the Barrier, generally unfathomable.

b. The actual Barrier.

c. Clear channel inside the Barrier, generally about 15 or 20 fathoms deep.

d. The inner reefs, e, shoal channel between the inner reefs and the shore.

F. The great buttress of calcareous rock, formed of coral and the detritus of corals and shells.

G. The mainland, formed of granites and other similar rocks.

N.B.—The proportions are enormously distorted, the perpendicular scale being fifteen or twenty times greater than the horizontal one.

CHAPTER III.

THE AUSTRALIAN GREAT BARRIER REEF.

IT is proposed to devote this chapter to a consideration of the general structure and most probable mode of origin of the Great Barrier Reef of Australia. Of its kind, or, in fact, of any coral edifices in the universe, it represents the most colossal. Built up by direct and indirect agencies of soft-fleshed polyps of multitudinous form and colour, it flanks the Queensland coast, excepting for the presence of a few narrow intersecting channels, for a distance of over twelve hundred miles.

Its marvellous extent and nature were, as related in the introductory section, first brought into prominent notice through the famous explorations of Captain Cook, for whose earliest account of many of the Barrier's most striking peculiarities, the reader may be referred more particularly to Volume II., 1821 Edition, of his famous "Voyages." The whole coast-line embraced by the Great Barrier Reef, from Sandy Cape to Torres Strait, bristles on the chart

with names, conferred by that intrepid navigator, whose very titles and significance serve to distinguish them conspicuously from those of any subsequent explorer. As samples of his nomenclature, such names may be cited as those of Break-sea Spit, Thirsty Sound, Repulse Bay, Trinity Bay, Providential Channel, Possession Island, and Capes Capricorn, Upstart, Tribulation, and Flattery. All of these, and a multitude of others associated with this coast-line, carry with them a most unmistakable Cookian ring. Having accomplished the task he set himself, albeit attended by many miraculous escapes from shipwreck, Captain Cook brought his vessel, the *Endeavour*, safely from Hobart and Sydney, to Possession Island, in Torres Strait, and thence proceeded, *viâ* New Guinea, to Timor and Java. He was thus the first to thread completely, and open up for navigation, the great Indo-Australian highway now known as the Inner Route.

Next in order to Captain Cook's voyage of discovery the names of Flinders, King, and Bligh are most intimately associated with tentative explorations of Torres Strait and the Great Barrier regions. The first thoroughly systematic survey of this important and very extensive conjoint area is, however, associated with the voyages of H.M.S. *Fly* and *Bramble*, prosecuted in the years 1842-1846, under the command of Captain F. P. Blackwood, R.N. The express object of that very important surveying cruise is graphically set forth in the "sailing orders" despatched from the Admiralty to Captain Blackwood, which read as follow:—

"Whereas, a large proportion of the vessels trading to the South Sea, and to Australia, are obliged to return to Europe, or proceed to India, by way of Torres Strait; and whereas many of these vessels, when weak-handed, in order to avoid the frequent anchorage necessary in the in-shore passage, by what is called King's Route, stand out to sea till an opportunity offers for making one of the narrow gaps in the Barrier Reefs, through which they steer for the Strait; and whereas, several vessels have thus been lost, there being no other guide to these openings than the casual observation of latitude which is often incorrect, there being no land to be seen till entangled within the reefs, and no chart on which the dangers are correctly placed.

"We have therefore thought fit for the above reasons, to have the Great Barrier Reef explored and to have those gaps surveyed, in order that some means may be devised for so marking the most eligible of these openings, that they may be recognised in due time, and passed through in comparative safety; and having thought fit to entrust you with the command of an expedition to effect these objects, we hereby require and direct you to take Her Majesty's cutter *Bramble* under your orders, and when she and Her Majesty's Ship *Fly*, under your immediate command, shall be in every respect ready for sea, to proceed to the island of Madeira . . . ; and then losing no further time, you are to repair to Sydney.

"Having refitted your vessels, recruited your provisions, and refreshed your crews, and having procured all the information respecting the Barrier Reefs and openings that can be obtained there, you will proceed to carry into execution the following objects; and notwithstanding the order in which they are here placed, we leave the several periods of their performance to your discretion.

"1. The survey of the exterior or eastern edge of that vast chain of reefs which extends almost continuously from Breaksea Spit to the shore of New Guinea.

"2. The thorough examination of all the channels through the Barrier Chain, with detailed plans of those which offer a secure passage.

"3. When you have examined them all, and considered their several advantages and difficulties, and determined which of them will offer the speediest and safest passage for the generality of merchant vessels, you will endeavour to devise some practical means of marking them by beacons of wood, stone, or iron, so placed on their outer islands or cays, that they may serve to guide those vessels to a certain and safe landfall.

"4. The position and dimensions of the several detached reefs and shoals which lie to the southward of the Great Barrier, and which appear, though with long intervals, to stretch towards Howe Island.

"5. The Bellona, Bampton, Mellish, and other reefs to the westward of New Caledonia may be considered as one large group, and are probably the remnants of a ridge of submarine hills, which, taking a parallel direction to the barrier, form, between it and them, the wide sea channel of approach to the barrier openings. All these rocks, as well as the Farquhars, must be explored and charted so as to define the eastern and western limits of that channel.

"6. In the more immediate mouth of Torres Strait, the reefs, islands, and intervening passages, having been discovered at different periods, and laid down by different authorities, assume a most complicated appearance, but by carefully collating what has been done by Flinders, Bligh, King, and other navigators, you will probably succeed in fixing on some comparatively safe channels, by which vessels may pass through from the eastward, and you will consider this to be one of the most important objects of the expedition.

"7. In Torres Strait it does not appear that to the northward of Prince of Wales Islands any good channels will be found, and we do not wish that you should spend any valuable time there, nor even between them and Endeavour Strait; but of this latter strait a complete survey, with its tides and soundings, with clear sailing directions, and with its dangers well distinguished by any sea-marks that can be adopted, will be a real boon to the mariner."

The instructions and suggestions embodied in the foregoing Admiralty orders were faithfully and successfully carried out, although with the result of the Raine Island Passage being elected, as giving the most ready access to Torres Strait from the Pacific Ocean outside the Barrier. This passage, as is mentioned in the introductory notice, was afterwards abandoned in favour of the wider and more northern Bligh (or Great North-East) Entrance, in consequence of the extreme intricacy of the route through the reefs at this point, and the absence of sheltered anchorage in its vicinity. The most gratifying fact associated with this survey was the appointment of the accomplished geologist, Professor J. Beete Jukes, as naturalist to the expedition. From his pen subsequently emanated that standard work, "Narrative of the Surveying Voyage of H.M.S. Fly," which embraces the most ample information extant concerning the conspicuous structural features of the Australian Great Barrier Reef.

In order to place the reader thoroughly *en rapport* with the chief topographical details hereafter given, a map of Queensland, including the Barrier district and the more important recorded soundings, has been reproduced from the Admiralty charts as an accompaniment to this chapter.

In the following general description of this most remarkable coral edifice, which will now be proceeded with, those prominent features the discovery and the record of which were originally associated by Jukes with the *Fly* narrative will as far as possible be embodied in consecutive succession, with due acknowledgments.

Adopting the sailing route followed originally by H.M.S. *Fly* and *Bramble*, and most other craft that have been employed in making a survey of, and otherwise investigating, the Great Barrier formation, the author proposes to begin examination of this wonderful structure at its southernmost extremity. The first point touched and commented on in Mr. Jukes' narrative is an islet of the Capricorn group, referred to in the text as the First Bunker's Island, but accompanied by a full-page illustration, in which Lady Elliot Island is characteristically figured. This island, which is intersected by the parallel of 24° 5″ S., represents the most southern islet of coral formation in the Barrier system. It is also the most southern point in this vast system that is associated with the calcareous conglomerate of which all coral rocks or reefs are compounded. While Lady Elliot Island and the adjacent reefs thus constitute the first area that would be made the subject of a systematic survey, they also bring to the fore a problem of high interest concerning the actual line of demarcation of growing reef-corals and reef-formation. It has been a generally-accepted axiom, hitherto, that the formation of reefs is indissolubly associated with the life, growth, and decay of a certain class of corals that are universally distinguished as reef-corals. Wherever the conditions favour the growth of those specific forms of coral, there also, is it commonly held, coral-reef formation must be in progress. The two phenomena, however, the author is in a position to demonstrate, are not necessarily concurrent.

The limit of distribution of typical reef-forming corals, and their more abundant disintegrated residua, extends, as a matter of fact, considerably to the south of Lady Elliot Island, but without giving rise to a trace of reef-formation. In Moreton Bay, at the present day, masses of the dead coralla of at least two species of Madrepora, the one a shrubby type allied to *M. decipiens*, and the other a corymbose species most nearly resembling *M. convexa* or *M. millepora*, may be collected at low spring-tide in the vicinity of Mud Island. These Madreporæ, it should be observed, are all *in situ*, just as they originally grew, and are covered by from one to two or three feet of water only, at ordinary low spring-tides. Associated with these dead Madreporæ there in many instances occur the living coralla of certain other species, and among them, more especially, a coral differing apparently in no essential respect from the Red Sea variety, *Favia Ehrenbergii*. This Astræaceous coral forms sub-spheroidal massive colony-stocks, varying from a few inches to two feet or more in diameter, such larger coralla often weighing over one hundredweight. The author collected, more rarely interspersed among these Faviæ, small living coralla of a Porites, and of a species of Psammoseris. In the earlier days of the colony, thirty or forty years ago, these Moreton Bay corals, including, more particularly, the massive Faviæ, were systematically collected, in barge-loads, for the purpose of making lime. By these means, beyond doubt, the original abundant growth of coral in this special area has been materially diminished.

Moreton Bay is of considerable dimensions; its extreme length, from Caloundra in the north to Southport in the extreme south, being no less than one hundred miles. It is practically

land-locked throughout its entire extent by the three long narrow islands of Bribie, Moreton, and Stradbroke, which, from north to south, form a natural mole or breakwater against the incursions of the Pacific Ocean. The chief gap, that most extensively used for shipping, occurs between the Moreton and Bribie islands; it is some five or six miles wide, and is known as the North Passage. The second-largest gap, distinguished as the South Passage, intervenes between Moreton and Stradbroke islands. It is less than a mile wide, and is passable, for large vessels, only under favourable conditions of the tide. The remaining gaps, between Bribie and the mainland, in the north, and Stradbroke and the mainland, in the south, are narrow, shallow, and available only as passages for the smallest craft. This categorical explanation of the topographical features of Moreton Bay may prove of service when an intelligible interpretation of its existing conditions of coral-growth is being sought.

Mud Island, Moreton Bay, in whose vicinity the various corals just referred to are still growing, or formerly grew, is situated at a point between Moreton Island and the mainland, close to the centre of the bay; no corals, either living or dead, occur to the south of it. Northwards, on the other hand, in the vicinity of the township of Humpybong, the mainland beach for many miles is made up of shells, sand, gravel, and a very considerable admixture of dead coral fragments. Among the types identified, the species of Favia, and the two Madreporæ previously reported from Mud Island, constitute the most abundant varieties; and, in the case of the Madreporæ, the branches thrown up by storms are often of considerable size. In addition to the foregoing, two other genera, which were not found at Mud Island, are here represented. These include a Turbinaria, apparently identical with *T. cinerascens*, and a species of Cyphastræa. The original growing-beds of the beach-stranded corals could not be precisely determined. They lay, as far as could be ascertained, a mile or so off the coast.

Two highly interesting and important questions arise in association with the facts just related. In the first place, how comes it that, with these various typical reef-constructing corals abundantly represented, in both the living and the dead conditions, no reefs or reef-rock conglomerates are constructed? Secondly, what causes or conditions have led to the destruction of the coralla of the genus Madrepora in Moreton Bay, and this to such an extent that no living specimens can now be found there? The first of the questions raised is of special interest, since upon its solution the interpretation of the most important phenomena of reef-construction would appear to rest. The composition of ordinary reef-rock out of the consolidated *débris* of dead and broken-down corals, and the local intermixture of the same with fragments of broken shells and gravel, have been previously dealt with and illustrated in association with the Photo-mezzotype plate No. XXXII. The ingredients embodied in the specimens, which are represented by Figs. 1 to 4, in the plate quoted, and were collected on the beach of Sweer's Island, in the Gulf of Carpentaria, correspond in every essential detail with those of Humpybong Beach, in Moreton Bay; but, in this latter instance, they possess no element of coherence,

and consequently cannot form a reef. The foregoing evidence is practically conclusive in support of the view put forward in association with the descriptive account of the plate just quoted: namely, that coral-reefs are produced in the tropics, not with relation so much to the intrinsic reef-constructing properties of the specific coral polyps, but with relation to the rule that reef consolidation (or the amalgamation of coral *débris* into a more or less solid, coarse or fine, concrete, or into a finer-grained, compact limestone) is associated only with the rapid evaporation of the lime-saturated sea-water on inter-tropical, tidally-exposed, coral banks or beaches. As related in the descriptive text quoted, granite-like lumps of the size of cobble-stones are, on the beach at Thursday Island, bound together, under like conditions, by the same tenacious calcareous cement.

Should further investigations prove that this interpretation of coral-rock conglomerate limestone construction is correct, it will assist materially towards elucidating the extent to which subsidence has been associated with the building up of any particular reef. For, in such case, the occurrence of typical consolidated coral-rock at a lower level than that of ordinary low spring-tides will be a certain indication of degradation from its original plane of elevation. As intimated in an early page (p. 71) of the preceding chapter, this same phenomenon logically accounts for the non-formation of reefs by the many luxuriantly growing Madreporaria, Lophohelia, Amphihelia, Dendrophyllia, &c., that form thickly-covered banks, often of many miles in extent, in abyssal depths off the European coast. It was postulated in the previous reference to this subject that, if these abyssal corals could be transported to shallow seas within the tropics, they would participate as substantially as Madreporæ, or other generally recognised reef-species, in the function of reef-construction. Approaching, and proving, the same postulate (*i.e.*, that coral-reef conglomerate and limestones are formed within inter-tropical tidal areas only, and altogether independently of the associated coral species, from a diametrically opposite avenue of access), it has now been incontestably shown that typical reef-corals, specifically identical with those which, a degree or two farther north, enter extensively into reef-construction, are, in extra-tropical waters, unassociated with such a function. Temperature, therefore, and not the specific varieties of Madreporaria, represents the prime factor in reef-construction; and in this connection it may be confidently affirmed that the presence of coral conglomerate and limestone, in any fossil deposit, indicates with tolerable certainty that a tropical climate prevailed during the epoch of its formation, concurrent, in all probability, with its occupation of a plane of elevation above that of ordinary low spring-tide.

The second question raised with relation to the Moreton Bay coral-growth is that of the cause of the wholesale destruction of the originally abundant and luxuriant colony-stocks of at least two distinct species of the genus Madrepora. The coralla of these Madreporæ may still be obtained in abundance on their original site, exhibiting every appearance of having gradually and quietly succumbed to some newly invading conditions inimical to their welfare. All

W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

LOW WOODY REEF, OUTER BARRIER SERIES, No. 7.

the main branches and the minor branchlets are perfectly preserved ; and it is only on account of the absence, through erosion, of the slender projecting edges of the component corallites, that any difficulty attends their identification. As previously remarked, the most abundantly represented types are closely allied to, if not absolutely identical with, the essentially cosmopolitan Barrier species, *Madrepora millepora* and *M. decipiens.* The most painstaking search, including numberless dredging operations, and the offer of substantial rewards, to fishermen and others, utterly failed to bring to light evidence of the present existence of any living coralla of these varieties, and it seems to be unquestionably certain that the genus Madrepora is now extinct in Moreton Bay. No knowledge, moreover, could be elicited with reference to their having occurred in the living state within the epoch of the colony's settlement, some fifty years ago Thus, a very considerable interval has apparently elapsed since they flourished in this locality. The first opinion entertained concerning the remarkable decadence of this coral group was that either the climatic conditions had altered, ushering in a temperature colder than these corals could withstand, or that a local elevation of the district had raised their growth-site to a plane in which, during the winter months more especially, they would be subjected at low spring-tides to similarly fatal atmospheric influences. A further consideration of all the conditions has, however, led to a somewhat different interpretation.

The geographical configuration of Moreton Bay was briefly summarised in a previous page, the circumstance of its area being almost completely hemmed in by a chain of three long narrow islands, which stretched between the mainland points at the head of the bay being especially alluded to. These islands, Bribie, Moreton, and Stradbroke, although rising to several hundred feet, are composed almost entirely of drifted siliceous sand, thrown up by the outside ocean. The peripheral contours of the said islands and of those of the labyrinths of sandbanks that abound in their vicinity are continually changing, and their bulk is undoubtedly augmenting. Dredging operations have, in fact, to be continually carried on in order to maintain navigable channels through the gaps between Moreton and Bribie, and between Moreton and Stradbroke Islands. The sand accumulation still in progress has, it may confidently be assumed, been in operation for centuries, indicating at the same time a period, not so very remote, when the existing accumulations were much less developed, and there was consequently more open communication with the outer ocean. It was under these conditions, it may be supposed, that the Madreporæ flourished, although it is not here suggested that the gradual shutting out of the freer access of the open ocean was the most potent cause of their extinction.

The fact remains as yet unnoticed that two considerable rivers, the Brisbane and the Logan, in addition to many minor streams, discharge their waters into Moreton Bay. During heavy floods the amount of fresh water pent up in the bay, and hindered from escaping through the presence of the chain of islands, and the associated sand-banks, above referred to, is very

considerable, and may endure for a lengthened period. Within recent years, and notably in 1887, the floods were so heavy and of such long duration that even the oysters were destroyed wholesale. This fact furnishes, in itself, a ready clue to the extinction of the Madreporæ; these corals, being very impatient of any admixture of fresh water, succumbed, in all probability, under the influences of the first abnormally heavy flood that occurred after the free access of the sea became impeded by the accumulated sand-bars. The survival and continued growth of the massive Faviæ is explained by the fact that they represent a species that can thrive in water of much less dense specific gravity than the essentially oceanic Madreporæ. The same explanation applies to the Porites and Psammoseris found growing, sparingly, in its vicinity. This one area, off Mud Island, where they still survive, constitutes the last remaining locality favourable to the growth of these most southern outpost representatives of the Great Barrier reef- though reefless-corals, it possessing the freest communication, under existing conditions, with the waters of the open sea, combined with immunity from the deleterious influences of shifting sand.

Northwards from Moreton Bay, there is one other coral-producing area that demands brief notice. This is Harvey Bay, which intervenes between the mainland and the long irregular island known as Great Sandy or Fraser Island. This bay is contracted at its southern extremity into a narrow strait, but widens out and is entirely open to the sea towards the north. Sandy Island, as its name denotes, is composed, like the islands flanking Moreton Bay, almost entirely of drifted siliceous sand; and there is but little ground within the confines of Harvey Bay that is suitable for coral-growth. Among a small assortment that has been obtained from the northern extremity of the bay, a species of large-celled Turbinaria is most abundantly represented. Members of this same generic group, it is worthy of remark, constitute the dominant representatives of the Madreporarian class in the vicinity of Sweer's Island, in the Gulf of Carpentaria, where the water in winter is occasionally below the tropical isotherm of 68°.

Great Sandy, or Fraser Island, as it is otherwise known, is fully one hundred miles in length. Towards its southern moiety it encloses the famous oyster-growing area, known as Wide Bay, into which the Mary River falls. Its northern end is the promontory of Sandy Cape, about 400 feet in height, from the foot of which projects seawards that long tongue-like bank of submerged sand over which the sea is continually breaking, which received from Captain Cook the name of "Break-sea Spit." In the Admiralty charts this sand-spit is set down as being composed of sand and dead coral. In earlier days, when the Madreporæ flourished in Moreton Bay, a bank of growing coral, apparently, occupied this site. At the present day, not only has the living coral vanished, but its dead remains have been engulphed in sand.

There are one or two facts of interest that invite record in association with Sandy or Fraser Island. In close vicinity to the lighthouse, at its north end, examples of apparently

lightning-fused aggregations of siliceous sand may be obtained in tolerable abundance. Mr. Darwin, in his "Voyage of the Beagle," records the occurrence of similar structures among sand-hillocks on the shores of the La Plata, near Maldonado. Each Sandy Island specimen consists for the most part of a central solid or tubular axial core, several feet in length, and three or four millimetres in diameter, around which subtend, in some instances, irregularly granular, and in others thin crest-like, ridges, which may measure three or four centimetres in width. In the last-named variety the crests, or ridges, while presenting no absolutely definite plan of arrangement, commonly number three or four, and diverge at equal angles with respect to one another, and to their centre.

Great Sandy Island is the proud possessor of a story of its own particular sea-serpent, which, if space permits, may find an appropriate place in the chapter on "Potentialities." Its introduction at the present juncture might prove inimical to the calm consideration of weightier scientific problems.

Bidding adieu to Break-sea Spit and its concourse of troubled waters, it takes one but a few hours of either sailing or steaming, north, to arrive at Lady Elliot Island. This island, with the surrounding reefs, represents, as previously related, the most southern islet or reef of the Barrier system; constituting, in point of fact, a sort of outlying bastion of that stupendous coral-constructed fortification which, with irregularly-recurring gaps, stretches from this point to within a few degrees short of the equator. The distance of Lady Elliot Island from Break-sea Spit is thirty-two nautical miles, and that between it and the next islet of the Capricorn-cum-Bunker group, just ten miles less. From Round Hill, the nearest point, due west, of the Queensland mainland, it is distant fifty miles, and from the outer edge of the shallow soundings, of from fifteen to thirty fathoms, which characterise the greater portion of the channels and water-areas that intervene between the outer reefs and the mainland, only two miles. Beyond this point, due east, over two hundred fathoms without bottom, is, as indicated in the Admiralty charts, immediately reached. Lady Elliot Island, when visited by Professor Jukes in the year 1843, as described and illustrated by him in the "Voyage of the Fly," was the abode of innumerable sea fowl. Now, it is the site of a first-class light-house, which, in conjunction with that on Sandy Cape, Great Sandy Island, illumines the broad entrance, *viâ* Curtis Channel, to the inner route along the Queensland coast to Torres Strait.

The physical aspect of Lady Elliot Island, as embodied in Mr. Jukes' description, remains, with the exception of the destruction and removal of the greater portion of the trees, unchanged at the present day. His account of it may, therefore, be reproduced verbatim. Writing of it as having given him his first acquaintance with a coral island, he says:—

"The beach was composed of coarse fragments of worn corals and shells, bleached by the weather. At the back of it a ridge of the same materials, four or five feet high and as many

yards across, completely encircled the island, which was not a quarter of a mile in diameter. Inside this regular ridge were some scattered heaps of the same stuff, the whole encircling a small sandy plain. The encircling ridge was occupied by a belt of small trees, while on the plain grew only a short scrubby vegetation, a foot or two high. The materials of the encircling ridge were quite low, and thinly covered with vegetable soil among the trees; but the sand of the central plain, which was dark brown, was sufficiently compact to be taken up in lumps, and a little underneath the surface it formed a kind of soft stone, with embedded fragments of coral. Some vegetable soil also was found, a few inches in thickness in some places, the result of the decomposition of vegetable matter and birds' dung.

"On the lee, or north-west side of the island, was a coral shoal or bank, sloping gradually off, from low-water mark for about a quarter of a mile, when it was two or three fathoms under water. Immediately beyond this was a depth of fifteen fathoms. On the south-east, or weather side of the island, was a coral-reef about two miles in diameter, having the form of a circle of breakers, including a shallow lagoon. Among the breakers, on the external edge of the reef some large black rocks showed themselves above water here and there all around. The lagoon inside was shoal, having two or three fathoms' water occasionally over spaces of white sand, the rest being occupied by flats of dead and living coral, of which the former was left dry at low water. In this lagoon we saw both sharks and turtle swimming about, and there were upwards of thirty fine turtle 'turned' when the boats first landed. One island was well-stocked with birds, of which black noddies and shearwaters were the most abundant; the next in number being terns, gulls, white herons or egrets, oyster-catchers, and curlews. The trees were loaded with the nests of the noddies, each of which was a small platform of seaweed and earth, fixed in the fork of a branch. They had one rather elongated lightish brown egg, rather less than a hen's egg. The shearwaters burrowed in the ground two or three feet; their eggs were larger, rather pointed and speckled, and streaked with black.

"On the south side of the island, on the beach, were exposed some beds of pretty hard rock, formed of fragments of corals and shells, compacted together in a matrix of still smaller grains of the same material. The beds were thin and slab-like, and rose from the lagoon at an angle of about 8° to a height of six or eight feet above high-water mark. Some of the finer slabs reminded me very much in general appearance of the slabs of the Dudley limestone. The colour of the rock was dark brown, hard externally, but the inside was white and much softer."

To the foregoing description of the physical features of Lady Elliot Island, given by Mr. Jukes, the author is in a position to add some data concerning its marine fauna, supplemented with a photographic illustration of the lagoon reef on the weather side of the island as exposed to view at extreme low tide. This illustration, Plate XXXIII.B, has been briefly referred to at page 55, with reference, more particularly, to the Bêche-de-mer, *Holothuria atra* (accidentally misspelt "*nigra*"), extended in the foreground. The considerable extent of

this reef, nearly two miles in diameter, as recorded by Jukes, together with its composition of intermingled areas of white sand and dead and growing coral patches, is characteristically portrayed in this photo-mezzotype illustration. The coral-fauna of this most southern reef differs in no essential respect from that of the reefs farther north. It includes representatives of almost all of the types that enter conspicuously into their composition. It is possible, in the illustration above quoted, to recognise a good many species, comprising conspicuous coralla of *Madrepora millepora*, *Pocillopora damicornis*, *Lophoseris cristata*, and species of Cœloria and Porites. Frilled Clams, *Tridacna compressa*, with their brilliant spotted mantles, and the long, slender-spined sea-urchin, *Diadema setosa*, abound in the intervening pools. Lady Elliot Island reef produces also that remarkable thick-spined Echinus, *Heterocentrotus mammillatus*, locally named the "Slate-pencil Urchin," represented by Fig. 13 of Chromo plate No. XI.

The turtles and the flocks of birds referred to in Mr. Jukes' narrative have become scarce, owing to the disturbing influences of the lighthouse colony, and the extent to which the island is visited by excursionists from the mainland. Fish, however, of both useful and ornamental kinds, abound within and without the margin of the reef. That species of bream, *Pagrus unicolor*, popularly known as the Schnapper, and rightly reckoned to be one of the finest of Australian food fishes, is particularly plentiful on the banks of the north-east side of the reef, and is the special subject of attraction to visitors. The reef-pools also teem with brilliantly-coloured small fishes, including notably the beautiful ultramarine-blue Labroides, with yellow fins, delineated by Fig. 9 of No. XVI. of the chromo-lithographic series; also the little black fish of the same genus, decorated with a single broad, pale peacock-green, stripe, represented by Fig. 4 of the same plate. Large blue-spotted sting-rays, *Myliobatis australis*, bask lazily in the intervening sandy patches; and among the deeper pools the bizarre tobacco-pipe fish, *Fistularia serrata*, photographically reproduced in Plate XLV., Fig. 5, may frequently be met. This fish in life is of a rich golden-brown hue, decorated along the sides with brilliant azure-blue spots. As may be surmised from its external features, it is a feeble swimmer, and can be easily cornered and captured. The species of Bêche-de-mer observed by the author on this reef, in addition to the form illustrated by Plate XXXIII., included the valuable commercial variety known to the trade as "Barrier Surf-Red" whose technical title, as identified by Professor F. J. Bell, is *Actinopyga mauritiana*.

On the way north from Lady Elliot Island, a whole chain of reefs and islands belonging to the Bunker and Capricorn groups is fallen in with. These groups occupy an area, running north-east by south-west, of about fifty-five miles. The majority of them constitute a fairly regular series at an approximate distance of between thirty and forty miles from the mainland coasts. One or two belonging to the most northern Capricorn series, however, approach as near as twenty-five miles. The permanently dry islets of the outer series number twelve; and, in addition to these, there are eight charted reefs, which are laid bare

to the height of two or three feet only at low water. The islets, none of which exceeds a mile in its greatest length, agree in their physical character with Lady Elliot Island, previously described. Like that islet, they are of uniformly coral formation, raised some few feet only above high tide level, and are associated, in the majority of instances, on their most weather-exposed, eastern, side, with an irregularly ovate or annular reef, including an enclosed lagoon, that usually occupies three or four times the superficial area of the islet. The same irregularly annular or ovate contour, with an enclosed lagoon, distinguishes the separate reefs. Collectively, therefore, the members of the Capricorn and Bunker groups furnish an appropriate illustration of the atoll-like reefs and islets recognised by Darwin, quoted at page 75, as frequently occurring in association with isolated banks in comparatively shallow water. True atolls, as distinctly defined by Mr. Darwin, whilst exhibiting corresponding contours, arise abruptly from very considerable, or, it may be, abyssal, depths. From fifteen to twenty-five or thirty fathoms are the deepest soundings obtainable outside the edges of any of the pseudo-atoll reefs of the Capricorn and the Bunker groups.

A highly characteristic illustration of the marginal area of one of these atoll-like reefs, together with the distant view of a neighbouring coral-islet of the Capricorn group, is given in Plate XXX.B. The islet on the distant horizon in this picture is known as Heron Island; it is about a mile in diameter, and consists of a bank of white coral-sand and conglomerate, raised but a few feet above the water, and thickly overgrown with trees, whose tops reach to an elevation of sixty feet above high-tide level. An extensive reef, between five and six miles long, and about two in width, subtends in an easterly direction from the island; but it is necessarily invisible from the point of view at which this photograph was taken. The foreground area included in the field of view represents the north-easterly edge of Westari reef, which is separated from Heron Island by a channel about a mile wide, and from eighteen to twenty fathoms deep. Its most conspicuous feature, represented by the huge rock-boulders that bestrew its surface, has already been the subject of remark in the earlier, plate-descriptive, chapter; as there explained, masses of the coral-conglomerate have been torn off the outer edge of the reef and hurled to their present position during storms of abnormal severity. Similar boulder-strewn areas characterise portions of the marginal edges of most of the coral reefs and islets throughout the Barrier system, and are a standing monument to the violence of the storms with which this region is visited. The largest of the rock boulders in this illustration is from five to six feet long, and from four to five feet high; but the dimensions are in many instances three or four times greater. The larger, most weather-exposed, of these conglomerate blocks become blackened with age through encrustment with a species of lichen, and are then popularly known as "nigger-heads." Although most abundantly cast up on the south-eastern (or normal weather) side of the reefs, these conglomerate boulders may, as in the present case, occur on the northern face, which represents, in point of fact, that aspect

W. Saville-Kent, Photo. London Stereoscopic Co. Rep

CRESCENT REEF, OUTER BARRIER SERIES, No. 6.

upon which the most violent storms, of hurricane force, strike the reefs during the prevalence of the north-west monsoon.

The extreme edge of Westari reef, having its position indicated by rippling waves, in Plate XXX., is very ragged and precipitate, and hollowed out into deep gulches, from which, probably, the stranded rock boulders in the foreground were originally torn. The reef-rock itself is full of "potholes," sometimes several fathoms deep; and among them it is necessary to tread circumspectly. These hollow potholes teem with brilliantly-coloured and grotesquely-shaped fish of innumerable varieties, constituting veritable aquaria with side walls composed chiefly of living corals of various tints. In photographs taken nearer the edge of the reef, when the tide was a foot or two lower, its surface is shown to be covered to a considerable extent with the growing coralla of two corymbiform species of Madrepora, pronounced by Mr. G. Brook, F.L.S., to be *Madrepora prostrata* and a variety, *compacta*, of *Madrepora millepora*. Other species of the genus, collected during an hour or so's exploration of this and the neighbouring "North-West" reef, included, as identified by the above-named authority, *Madrepora hebes, fruticosa, decipiens, gemmifera, seriata, pectinata, surculosa, variabilis, sarmentosa, recumbens, bœodactyla, digitifera,* with *Madrepora (Isopora) palifera* and *cuneata*. In addition to these, a host of Astræaceæ and other Madreporaria that yet await identification were obtained. The growth habit of the last-named species of Madrepora, *M. cuneata*, is peculiar. This species, with a few other varieties, has been referred by Dana to the sub-genus Isopora, on account of the fact that the subdivisions of the coralla are not associated with a single, usually larger, terminal, or growing, corallite, as is usual among all the ordinary representatives of the genus. In this particular species, *M. cuneata*, the coralla on the Westari and the North-West reefs are encrusting forms, spreading out in ridges from a central point over areas of the platform-reef, which, having a thin sheet of water flowing over them from the inner lagoon, at even the lowest tide, are thus continually submerged. In deeper water on Westari reef, the same species of coral, in company with *Madrepora palifera*, forms robust, erect folia, of considerable dimensions. The life-colours of the coralla of this species are not so attractive as those of many of the members of the genus. They are chiefly light buff in hue, but variegated, to the extent of the edges of the corallites and their contained polyps being lemon or primrose colour.

The beach near high-water mark of North-West Island yielded many specimens of interest that had been thrown up from deep water in heavy weather. These included the remarkable flexible coral, *Isis hippuris*, a representative of the Gorgoniaceæ, in which the corallum is composed of alternate joints of black horn-like and white calcareous matter, which will be found illustrated by Chromo plate XI., Fig. 1. A red Hydroid coral, *Distichopora coccinea*, and the Black coral, *Antipathes abies*, both of which are delineated in the same plate, together with some very fair examples of sponges, having as fine a texture as many of the ordinary commercial species, were

collected from the drift accumulations on North-West reef. These subjects will receive attention under their respective headings. A few casts with the dredge and tangles, made off the reef in a depth of about twenty fathoms, produced an abundance of corals, referable to two single species only, of the genera Seriatopora and Pocillopora, together with a few specimens of the Solitary coral, *Heteropsammia Michelini.*

Before leaving the Capricorn group of reefs and islets, it has been thought desirable to include a further abstract from Mr. Jukes' narrative of H.M.S. *Fly's* survey of this particular area, in which are embodied many interesting data concerning the geological composition of the reefs. As a geological specialist, he was in a position to speak *ex cathedra* upon this subject. Two coral islets, One-Tree Island and Heron Island, the latter visible on the horizon of the photographic view reproduced in Plate XXX., were the field of Mr. Jukes' explorations. The diary of his experiences is as follows :—

"Jan. 11.—Landed on this (One-Tree) island, which exhibited the same general features as Bunker's first island, with some modifications. The external ridge of loose coral fragments was loftier and steeper, owing, I believe, to this island being rather more on the weather, or at least the south side of the reef. Inside, the island sloped down every way towards the centre, forming a shallow basin, in the middle of which was a small hole of salt-water at or near the level of the sea. The inside slope was covered with low succulent plants with pink flowers (Mesembryanthemum) and low trailing bushes. On this green carpet were multitudes of young terns that fluttered before us like flocks of ducklings, with the old birds darting and screaming over our heads. In the single tree (which was, in fact, a small clump of the common Pandanus of these seas with its roots exposed above ground) was a large rude mass of old sticks, the nest of some bird of prey, probably the osprey. To the northward and eastward of the island stretched the shoal lagoon, its bottom of clean white sand, and dark patches of dead and living coral, bounded by the usual rim of snow-white breakers. Just round the island, part of the body of the reef was now exposed at low water. This was a flat surface of about a quarter of a mile in width, dotted here and there with pools and holes of water. It consisted of a compact, tough, but rather soft and spongy rock, many loose slabs of which, two or three inches thick, were lying about. It was rather fine-grained, and only here and there exhibited any organic structure or remains. There were no signs of living coral, except a few stunted specimens in some of the deeper holes of the reef, where also were some dead masses still standing in the position of growth. The whole was very different from any preconceived notions of a coral reef, and I erroneously imagined it must be an exception to their general character; it looked simply like a half-drowned mass of dirty brown sandstone, on which a few stunted corals had taken root.

"Jan. 12.—We were anchored a few miles farther to the N.W. in the centre of a group of reefs and islands, under one thickly wooded island that afterwards obtained the name of Heron Island. In attempting to land at low water, we were compelled to quit the boat soon after getting

on the edge of the reef, and wade ashore a distance of a third of a mile. The bottom was very irregularly, but pretty equally, divided between white sand and blocks of dead and living coral, principally the former. On many of the rough blocks of coral there was scarcely a few inches of water, and many large masses, particularly along the outer edge of the reef, were high and dry. All the sandy spots, however, were about three or four feet deep, and as neither the sandy spots nor the coral-masses were anywhere continuous for more than a yard or two, we had a succession of wading and scrambling that was rather laborious. Arrived at the island, the first thing that took my attention was a large development of hard brown rock, like that on Bunker's Island. Both the island and the reef were elongated in an east and west direction, the island being half a mile long, and not more than 300 yards broad. It consisted in the interior of piles of loose sand, covered by a dense wood of pretty large trees, with broadish leaves, most of which had a white brittle wood, and grew in a singularly slanting position, the stems frequently curving at an angle of 45°, although three or four feet in circumference. The beach of the island was steep, about twenty feet high at low water, and composed partly of sand and partly of stone. The sand was very coarse, composed wholly of large grains and small angular pieces of comminuted corals and shells, with some larger worn fragments of both intermixed. The stone was of precisely the same materials, but very hard, and dark brown externally, although still white inside. It sometimes required two or three sharp blows with the hammer to break even a corner of it off. Its surface was everywhere rough, honeycombed and uneven ; the beds from one to two feet in thickness, with, occasionally, in the fine-grained parts, a tendency to split into slabs or flags. It was perfectly jointed by rather zig-zag points crossing each other at right angles, and splitting the rock into quadrangular blocks of from one to two feet in the side. As far as external appearance and character went, it might have been taken for any old roughly stratified rock. As to position, the strike of the rock was parallel to the direction of the long diameter of the island and reef, or east and west ; and it dipped on the north and south sides of the island to the north and south respectively ; or from the island towards the reef at an angle of 8° or 10°. At the east end of the island it was not visible, but at the west it appeared from under the sand in two places, in one being horizontal, and in the other having a slight flexure or anticlinal line, which ranged also east and west. The rock was in many places much worn by the wash of the breakers, which had also a good deal undermined it in some places, and many blocks had fallen down in a line. The joints were parallel to the dip and strike respectively. The rise and fall of tide here was fourteen or fifteen feet, and at high water the upper part of the rock was just about covered ; at low water the reef was dry for a small space all round the island. Now the question is how or under what circumstances did the loose calcareous sand and fragments become hardened into solid stone, acquire a regular bedding and a jointed structure, and the plane of stratification assume an inclination of 8° or 10°. If it be supposed that a regular deposition and slope of 8° took place every high tide, and a gradual and successive induration went on, why does not the same thing take place now ? or why did not the loose sand

which composes the greater part of the beach in the same position become consolidated? Permanent springs containing carbonate of lime are, of course, improbable in so small a heap of low sand as the islet is composed of. Either, then, the stratification and consolidation is the result of a gradual deposition beneath the level of low water, in which case a movement of elevation must have taken place, which in so small a spot seems a difficult and gratuitous hypothesis; or else the present structure must have been produced in the *interior* of a mass of loose sand by the infiltration of sea or rain water, or some other cause of which we are ignorant. I say in the interior, for had it been on the outside, what was to defend it from the wash of the sea that is now breaking down the hard solid rock, and shifting and washing backwards and forwards the loose sand of which the present beach is composed? After the interior of such a mass of sand had been consolidated, the loose exterior may have been washed away and the solid rock exposed. The speculation concerning the structure of this little island may seem a very unimportant circumstance even to the geologist; but it is not so, as this same rock is found along every beach and on every island among the coral-reefs of Australia, and I believe in other parts of the world also."

The geological data and speculations connected therewith, embodied in Mr. Jukes' diary, herein reproduced *in extenso*, receive further notice in a later page of this chapter. Whether or not Mr. Jukes' description of a living coral-reef, as "a half-drowned mass of dirty brown sandstone, in which a few stunted corals had taken root," is actually as universally applicable as the associated context would seem to imply, is a subject which may be left to the decision of the reader already familiar with the photographic reef illustrations in this volume. To the majority of voyagers and explorers, however, who cannot pick and choose the most favourable times and tides for landing on them, the earliest, and it may be the most frequently renewed, acquaintanceships with coral-reefs and banks are equally productive of disappointment. Many a veteran fisherman, indeed, who has been connected for the greater portion of his life with the Barrier Bêche-de-mer and pearl-shell fishing industries, and to whom copies of the original photographs were submitted, was unacquainted with reefs laid bare, and exposing their coral groves and thickets to the extent portrayed in many of the accompanying plates.

Immediately north of the Capricorn Islands group, the wide entrance passage to the Inner Route, known as the Capricorn Channel, intervenes. This gap, which may be designated the chief entrance to the Inner Route from the south, is no less than sixty miles wide, and carries soundings of from thirty to over seventy fathoms that gradually shelve in from the open ocean. The outer boundary of this channel is represented by the Swain reefs, an archipelago of several hundred tidally-exposed reefs, very similar in character to Westari reef of the Capricorn group, which jut out oceanwards, forming part and parcel of the Barrier to a distance of one hundred and fifty miles east of the mainland. With the exception of two insignificant sand patches known as Bell Cay and Hixson Cay, this entire reef system is submerged at high water.

A brief account of the aspect of one of the reefs belonging to Swain's group, on which

Mr. Jukes landed, is thus given in his "Journal": "Feb. 4, 5, 6.—Running along and delineating the eastern edge of this large body of reefs, sometimes standing out into the offing to sound, and taking care on the approach of night to run into some of the openings, and anchor in a sheltered position among them. These reefs consist of a compact body of coral-masses, intersected by narrow channels of deep water; each mass varies in extent from one to several miles, some of them being almost dry at low water, others having lagoons or hollows of greater or less depth. A very common feature among them is a line of great detached blocks lying a little back from the outer edge of the reef, frequently not altogether covered even at high tide, and always quite exposed at low water. I landed on one reef from our anchorage on the evening of the 5th. We carried blue water from the ship for about half a mile, and then began to see the bottom in about seven fathoms, from which it shoaled gradually, but rapidly, till the boat touched the top of the coral branches. Scraping on, however, over these, and winding among the more solid masses of Mœandrina and Astræa, we reached some of the large dry blocks on the seaward edge of the reef. I found some of them to be huge masses of Mœandrina, six or eight feet in diameter, much waterworn and lying upside down, having been torn by some heavy sea from their place of growth on the weather edge of the reef, and washed two or three hundred yards back from it. Others were a species of massive Porites, while others again consisted of various corals, all matted and compacted together."

On the trend of the coast-line in a north-westerly direction, a considerable archipelago of islands, which present a distinct character from the reefs and islets hitherto enumerated, is encountered. The latter islets have been entirely of coral origin. We now, however, meet with a linear series of island-groups, which stretch for nearly two hundred miles, and are composed of igneous or metamorphic rocks, identical in character with those of which the foundations of the mainland are composed. The Percy, the Northumberland, the Cumberland, and the Whitsunday Islands represent these several groups in their consecutive order of occurrence, voyaging up the coast. They all lie within comparatively short distances, varying from ten to fifty miles, from the mainland shore, and in some instances rise to a considerable height. In the Cumberland and the Whitsunday groups more particularly, there are mountain peaks, such as those of Scawfell, St. Bees, Carlisle, and Hook Islands, whose heights exceed 1,000 feet. In these two more northern groups the irregular rocky cliffs and hillsides are, for the most part, covered with a dense growth of a handsome species of pine, Araucaria, which, when viewed from the steamer's deck, communicates a very picturesque, almost Scandinavian, facies to the associated landscapes. A nearer approach, however, eradicates this first impression, by revealing the admixture among the pines of palms, pandani, and many other plants of a tropical character. The ordinary steamer track through the Whitsunday Passage is justly regarded as one of the most picturesque bits of scenery on the Australian coast-line. Among other points of interest to which the traveller's attention will probably be directed is the remarkable aspect of Lion, or

Pentecost, Island, which for some distance, from a westerly point of view, presents the most perfect contour-resemblance to a lion couchant, with its head raised, after the manner of Landseer's masterpieces in Trafalgar Square.

Although coral does not represent the main element in the composition of the island groups now under notice, almost all of them are intimately associated with fringing reefs of it, and have interspersed, between and among them, detached banks and reefs of a purely coral origin. The outer border of the Barrier along this area is as remote as from eighty to one hundred miles from the mainland coast, while between its margin and the groups of islands above enumerated there intervenes a labyrinth of coral-reefs and shoals, all more or less completely covered at high water, similar in character to those which enter into the composition of Swain's reefs, previously referred to. A conspicuous feature of the fringing reef of M island, belonging to the Northumberland group, and of others in the same neighbourhood, was the predominance of the large, robustly branching or sub-foliaceous Stags'-horn coral, *Madrepora (Isopora) palifera*. This species abounds on the seaward margins of the reefs, growing to within a short distance of the surface at low-tide mark, from depths of two to three fathoms. The occurrence of this species in company with an allied variety, *Madrepora (Isopora) cuneata*, has been already noted in association with Westari reef in the Capricorn group. The considerable rise and fall of the tide, in the vicinity of the Percy and Northumberland Island groups more especially, is attested in Mr. Jukes' narrative, and in the Queensland Ports Office Sailing Directions. In Broad Sound, in the vicinity of St. Lawrence Creek, the spring tides exhibit a range of variation of not less than from eighteen to thirty feet.

A few hours' sailing along the Inner Route, in a north-westerly direction, brings the voyager abreast of Port Denison and Gloucester Island, just twenty-five miles from Hayman Island, the most northerly islet of the Whitsunday group. Gloucester Island itself is separated by a very narrow passage from the mainland, and between it and the outer margin of the Barrier, now about seventy miles from the shore, only one or two small islets of primitive rock-formation intervene. The entire remaining area, excepting the central navigable channel, is thickly studded with semi-submerged reefs and shoals similar in character to those of the Swain and the Capricorn series. The fringing reefs in the neighbourhood of Port Denison, including Saddleback Island, which is just outside Gloucester Island, have contributed extensively to the collection of photographic reef-views reproduced in this volume. Their diversified character is well exemplified in Plates V., Nos. 1 and 2 ; VII., VIII., Nos. 1 and 2 ; IX. and X., No. 2, of the Photo-mezzotype series. To these plates, in association with the descriptive letterpress in Chapter I., the reader who desires further information concerning the features and composition of the reefs of this district may be referred. The frontispiece, Plate I., of the photographic series, it may be mentioned, is exclusively representative of coral species collected in this Port Denison area of the Great Barrier district.

Following the inner route along its north-westerly course for another seventy miles, no other island group of primitive rock formation is encountered. The outer edge of the Great Barrier has, from its greatest distance from the mainland (one hundred and fifty miles off the Swain's reefs) trended gradually inwards, and is now, opposite Cape Bowling-Green, within the narrower, but still considerable, distance of fifty miles from the Queensland coast. At this particular point we arrive at the third considerable, or navigable, gap in the Barrier, which has received the name of Flinders' Passage. The Curtis and the Capricorn Channels, at the extreme southern limits of the Great Barrier, have been enumerated as constituting the first and the second passages. There is a feature of interest associated with Flinders' Passage and the two more southern Barrier openings, to which brief attention only will be drawn at this point, whose most important significance is reserved for future notice. This is the mouth of a river, the Burdekin, having an extensive watershed, immediately opposite Flinders' Passage gap. The watershed to the south, adjoining that of the Burdekin, is of much more considerable dimensions; it drains all the back country for an approximate superficial area of 40,000 square miles, in the united streams of the Mackenzie, Comet, Dawson, and Fitzroy rivers, and discharges itself into Keppel Bay, immediately opposite the wide portals of the Capricorn Channel. The next watershed of any importance, farther south, is that of the Burnett River, whose estuary immediately faces the Curtis Channel.

Fifty miles more sailing in the same north-westerly course, after leaving the parallel of Cape Bowling-Green and the Flinders' Passage, brings the voyager abreast of the Palm Islands, he having previously, some ten miles back, passed Magnetic Island, a short distance off the coast, in the neighbourhood of Townsville, Queensland's northern capital. With the exception of this island, and Hobourne Island and Nares Rock off Cape Gloucester, the entire distance, about 150 miles, between the Whitsunday and Palm Islands groups, is uninterrupted by any elevated rocks or islands of metamorphic or stratigraphical nature. Archipelagoes of coral-reefs and shoals abound, however, as throughout the superficies of the Great Barrier region.

Some half-a-dozen islets are included in the Palm Islands group. They occupy an area ranging from ten to twenty miles off the mainland coast; and their abundant fringing reefs have, as in the case of those of Port Denison, been extensively utilised for the illustration of this work. The Photo-mezzotype Plates Nos. IV., VI., X., and XXVIII. yield fair evidence of their diversity of aspect and composition. The collection of coral specimens made on these reefs was very considerable, and included many types that were not obtained farther south. The genera Oculina, Echinopora, and Tridacophyllum are especially noteworthy. Of the genus Madrepora, or Stags'-horn corals, some thirteen specific forms were collected, comprising the brilliant electric-blue variety of *Madrepora laxa*, represented by Plate IX., Fig. 6, of the chromo-lithographic series.

The precipitous land of the Palm Islands group is of granitic formation, and includes some peaks of considerable height. The Great Palm Island is over 1,800 feet high; Orpheus Island, 568 feet; and Pelorus Island, 924 feet. The coastal island of Hinchinbrook, within clear view, and lying some ten miles only to the north-west of the Palm Islands, attains, in accordance with the Admiralty charts, to an elevation of no less than 3,650 feet. As originally defined by Mr. Jukes, it is made up of broken masses of hills, covered with rugged knolls and sharp, inacessible pinnacles, and furrowed by deep and precipitous gullies and ravines. There are two minor navigable entrances (Palm and Magnetic Passages) through the Great Barrier, opposite the Palm Island and the Hinchinbrook groups. Although fifty miles from the mainland, they are significantly parallel with the estuary of the Herbert River, which drains the watershed next in order, northwards, to that of the conjoint Mackenzie, Dawson, and Fitzroy basin.

No feature of special interest is associated with the reefs intersected by the navigable course for the next seventy miles, northwards, from Hinchinbrook, all the reefs and shoals being of the uniform coral formation as those previously referred to. At about the point indicated, three openings occur in relatively close proximity; and the edge of the Barrier, at the same point, approaches to within thirty miles of the mainland coast. The reef passages referred to are, in their consecutive order from the south, the Flora Pass, the Grafton Passage, and the Trinity Opening. All three are contained within the narrow limits of less than forty miles, and probably represent the delta-like subdivision of a primarily single channel. The soundings immediately outside the Trinity Opening, more particularly, are deeper than those at any point so far passed. From Break-sea Spit up to the gaps now under notice, soundings taken off the immediate edge of the Barrier, as recorded in the Admiralty charts, fluctuate between one hundred and two hundred fathoms, with the exception of a single one of 365 fathoms, a little to the south of the Flora Pass, and opposite the estuary of the Johnstone River. Close against the outer edge of the Barrier at the Trinity Opening, as great a depth as 650 fathoms is recorded, with several in the near vicinity of over 250. On referring to the land chart, to ascertain whether in this case also any river estuary, by coincidence or otherwise, harmonises in its bearings with this Barrier gap, it will be found that the Barron River discharges its waters in such position, a little to the north of Cairns. This river is remarkable for its rugged, precipitous course and mighty waterfalls in the back country, one of which is seven hundred feet high. During the tropical flood seasons, the Barron River brings down a deluge of water that would materially affect the coral life of a reef lying across its track at a less distance than the present Barrier opening.

The reefs northwards of the Trinity Opening are much more continuous, or wall-like, along the Barrier's outer periphery than to the south of that passage. The interior reefs also are much more extensive, and constitute, in this respect, favourable collecting grounds for prosecutors of the Bêche-de-mer fishing industry. Green Island, some ten or twelve miles only out to sea

W. Saville-Kent, Photo.

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CRESCENT REEF, OUTER BARRIER SERIES, No. 7.

from Cairns, is a much-frequented central station for the collection and curing of all of the most valuable commercial species. A few days' encampment sufficed to supply the author with an extensive representative series of these esculent Holothuridæ, since contributed to the National Museum, and with a comprehensive collection of Madreporaria. The corals, in their general features, corresponded so essentially, although on a less luxuriant scale, with those of Rocky Island, dealt with a little later, that special notice of them at this point may be dispensed with.

A little north of the Trinity Opening, the outer margin of the Barrier approaches to within a little less than thirty miles from the mainland. The same near approximation to the coast is maintained for the next two hundred miles, at which point, about latitude 14° S., in association with the promontory of Cape Melville, its nearest approach, to within a distance of only twelve miles from the mainland, is found. This area includes some of the most prolific Bêche-de-mer fishing grounds in the Barrier district, which are extensively worked from the most northern mainland port of Cooktown. Low reefs and islets of purely coral formation constitute the dominant feature of the fishing grounds south of Cooktown and Cape Bedford. North of this point, however, there are a good many scattered islets of granite, or other primitive rock formation, which attain to a considerable height. Lizard Island, a little over twenty miles off the mainland coast, and about forty-five miles north of Cooktown, is one of the most conspicuous. It is composed of granite, and, rising to a height of 1,167 feet, is a useful beacon for the navigation of the mazes of the reefs. The two islands of North and South Direction, in the vicinity of the Lizard, are of the respective heights of 610 and 567 feet. Rocky Island, some ten miles due south of the Lizard, is about 200 feet high, and is associated with three or four outlying islets of similar granitic formation.

Rocky Island, above mentioned, and Low Woody Island, of coral formation, about ten miles farther south, are stations in whose vicinity the author obtained the most remarkably luxuriant photographic reef-views reproduced in this volume. These two islands constituted convenient centres for the acquisition of some of the most varied collections of Madreporaria derived from the Barrier district. No fewer than twenty-four species of the genus Madrepora alone were obtained from the Rocky Island reefs, and in addition to these a host of other varieties whose identification awaits accomplishment. The names of the species of the genus Madrepora which have been carefully worked out by Mr. Brook, are included in the following chapter on corals and allied organisms. The prolific character of the coral-growths on the Low Woody Island reefs is well exemplified by the Photo-mezzotype Plates, numbering XIII. to XVII. inclusive, whose descriptive details are embodied in pages 23 to 27 of Chapter I. The Lark Passage reef-view represented by Plate XII. is also within easy sailing distance of Low Woody Island, and was visited the same excursion.

All the illustrations enumerated assist to demonstrate the existence within this area of the

Barrier district of an abundant development of coral-reefs that present to the eye, under favourable conditions, a more pleasing aspect than that of "a half-drowned mass of dirty brown sandstone, on which a few stunted corals had taken root," applied, as quoted from Mr. Jukes' work on a previous page, in a wholesale fashion to the reef-scapes ordinarily exposed to view. On one occasion, a little to the north of the area now under discussion, Mr. Jukes appears to have fallen in with a luxuriant patch of growing coral very much akin to certain of those represented in the Low Woody views, although, from the context, it is evident that even in this instance the growing coral was not completely uncovered, but visible only through the clear, superjacent water. In their general features, however, the aspect and colours described so closely accord with those associated with the Low Woody and other analogous reefs illustrated in this volume that Mr. Jukes' descriptive paragraphs are herewith reproduced. Besides furnishing corroborative testimony concerning the brilliant hues of the growing reefs, recorded by the author in the plate-descriptive chapter, they endorse the evidence respecting the living tints of many of the individual corals and reef-fishes associated with the series of coloured plates. The paragraphs in Mr. Jukes' journal are as follow :

"I had hitherto been rather disappointed by the aspect of the coral-reefs so far as beauty was concerned, and though very wonderful, I had not seen in them much to admire. One day, however, on the lee side of one of the outer reefs, near the wreck of the *Ferguson*, I had reason to change my opinion. In a small bight of the inner edge of this reef was a sheltered nook, where the extreme slope was well exposed, and where every coral was in full life and luxuriance. Smooth and round masses of Mœandrina and Astræa were contrasted with delicate leaf-like and cup-shaped expansions of Explanaria, and with an infinite variety of branching Madræporæ and Seriatoporæ, with some mere finger-shaped projections, others with large branching stems, and others again exhibiting an elegant assemblage of interlacing twigs of the most delicate and exquisite workmanship. Their colours were unrivalled—vivid greens contrasting with more sober browns and yellows, mingled with rich shades of purple, from pale pink to deep blue. Bright red, yellow, and peach coloured Nulliporæ clothed those masses that were dead, mingled with beautiful pearly flakes of Eschara and Reteporæ ; the latter looking like lace work in ivory. In among the branches of the corals, like birds among trees, floated many beautiful fish, radiant with metallic greens or crimsons, or fantastically banded with black and yellow stripes. Patches of clear white sand were seen here and there for the floor, with dark hollows and recesses, beneath overhanging masses and ledges. All these, seen through the clear crystal water, the ripple of which gave motion and quick play of light and shadow to the whole, formed a scene of the rarest beauty, and left nothing to be desired by the eye either in elegance of form or brilliancy and harmony of colouring.

"This beautiful portion is, however, only to be seen on the extreme verge, and outer slope of a coral-reef, when circumstances are favourable for its examination, which is not often

the case. The flat surface of the reef is a dull affair enough, though many elegant corals may be seen in the detached pools, or in the parts which are permanently covered by water."

As recorded in Mr. Jukes' diary, and also by Darwin and other naturalists practically acquainted with coral life, the most luxuriant banks of growing coral are found on the least weather-exposed, or lee, sides of the reefs; and it is from such situations that the photographs reproduced in this volume were mainly obtained. Nevertheless, many of the apparently easily-injured species, such as the delicate vase-like coralla of *Madrepora surculosa*, are found flourishing beside the most robust forms amidst the weather-side breakers at lowest tide-mark. Characteristic photographs of such growths were taken by the author on the weather-side of Rocky Island; but the violence of the gale during the operations caused a vibration of the camera that rendered the negatives useless for the purposes of photo-mechanical illustration. Luxuriant as is the growth of coral in many of the reef-scapes reproduced in this volume, this luxuriance is much exceeded on sheltered portions of the reefs that are permanently submerged. Their sloping edges, down to a depth of three or four fathoms, as seen on a calm day over the boat's side, often reveal terrace upon terrace, or literally hanging gardens, of coral growth of every variety of form and colour. Specifically, these submerged corals do not differ materially from the types accessible on the surface or near the edges of the reefs at extremely low spring-tides, although in these more sheltered and permanently submerged positions they usually exhibit a more exuberant growth. In different localities, or separate portions of the same reefs, the dominating representatives of the more distinct specific types are as prevalent as on the tidally-exposed areas illustrated. Thus, one almost perpendicular bank may be completely covered with the spreading vasiform coralla of *Madrepora surculosa* or *pectinata*, usually of a pale-lilac or pink-brown hue, with pale-primrose or flesh-pink growing edges. Another submarine reef is as completely clothed with the brilliant rose-pink, minutely divided, clumps of *Seriatopora hystrix*. A third bank may include robust branching Stags'-horn varieties, resplendent with intermingling tints of electric-blue, grass-green, and violet, and comprising such specific forms as *Madrepora grandis*, *laxa*, *decipiens*, and *arbuscula*. Over a very large extent of the submerged reefs, the comparatively solid, smooth-surfaced, and more or less hemispherical, coralla of the Astræaceæ and Poritidæ monopolise the growing space, to the exclusion of the branching species; or, as abundantly illustrated in the photographs of the tidally-exposed reefs, almost every gradation of intermixture may obtain.

The area of the Great Barrier district now under notice embraces some of the most interesting land and coast marks associated with its earliest exploration by Captain Cook. A little below Cooktown, 15° 45′ S., is situated the Endeavour reef, upon which Cook's vessel of the same name stranded, and so narrowly escaped total wreck. The mouth of the Endeavour River, now the site of Queensland's most northern mainland town of Cooktown, is the natural harbour into which he managed to navigate his disabled vessel; the presumptive spot where he careened,

and repaired the various damages it sustained being now marked by a handsome monument to his memory. The summit of Lizard Island is the station from which Captain Cook reconnoitred the reefs, and decided upon attempting to pass out through the Barrier eastwards. He did so at a small gap in latitude 14° 32′ S., now known on the Admiralty charts as Cook's Passage. The two islands of North and South Direction were so named by this explorer on account of their utility, in conjunction with Lizard Island, as beacons. Captain Cook's re-entry within the mazes of the Barrier was accomplished through a similar narrow gap, named by him Providential Channel, some 150 miles farther north, whence he discovered the route to Torres Strait, now daily navigated, between the outer Barrier and the mainland coast.

Captain Cook was not aware of it; but there were, in the near vicinity of Lizard Island, two passages through the Barrier far more practicable than the one he penetrated. One of these, known as the One and a Half Mile Opening, is less than ten miles north of Cook's Passage, and the other, the Lark Pass, just forty miles south of the same point. None of the three passages, nor, indeed, any other that penetrates the Barrier farther north, is of the wide, open character that characterises the channels and openings to the south, previously enumerated; and it is significant in association with this phenomenon, that no large rivers, draining a considerable extent of back country, fall upon the northern side of the eastern coast. Such larger rivers as do exist flow westward to the Gulf of Carpentaria. At the same time, some correlation might possibly be established between the Endeavour River estuary and the Lark Passage, and between the estuary of Kennedy River and the First Three Mile opening, a little to the north of Cape Melville. In both instances the Barrier gaps lay some little distance to the north of the rivers' mouths, and the connection between the two is consequently not so obvious as in the examples previously recorded.

North of the promontory of Cape Melville, at which point the outer edge of the Barrier approaches to within twelve miles from the mainland, there is for the next 160 miles, or as far north as Cape Grenville, but little difference in the physical and geological features of this great reef area. The margin of the Barrier follows the trend of the coast at a distance varying from twenty to forty miles. Its main area is similarly occupied with half-sunken reefs and coral islets, supplemented occasionally by a few sheltered rocks or island groups of primitive formation. One such island group, known as the Howicks, occurs in the area just passed, some twenty miles south of Cape Melville. The highest point on the largest island of this series does not exceed 180 feet. The Flinders' group, situated off Princess Charlotte's Bay, the indentation to the west of the same cape, embraces some half-dozen exceedingly rugged islands, the largest of which yields an altitude of 829 feet. Within recent years this last-named group of islands has been the subject of attention in respect of the considerable quantity of oysters it produces, which are systematically collected and shipped to Thursday Island, Normanton, and Croydon. The species, *Ostrea nigromarginata*, is a large, coarse variety that

grows in abundance on the rocks at about half-tide mark, and requires considerable force to detach it from the rocks. An elongate shell of this species is illustrated by Plate XIV., Fig. 7, of the chromo-lithographic series. A further reference to the habits and characters of the species will be found in the chapter dealing specially with the oyster and oyster fisheries of the Barrier district.

Three lightships are stationed along the course between Cape Melville and Cape Grenville, to guide the passage through the intricate maze of reefs and shoals. The first, known as the Piper Islands Lightship, is a mile or so off Cape Melville. The Claremont Isles Lightship, the second, occupies a position a little less than ten miles off the mainland, about halfway between the two capes named. The most northern one, Piper Island, is twelve miles due south of Cape Grenville. Both the last-named stations have yielded specimens of interest. From the neighbourhood of the Claremont Lightship, more particularly, varieties of coral which have not been collected elsewhere, have been obtained by the lightship keepers, Mr. and Mrs. Wilson. Among these is *Madrepora ornata,* a new species, so named by Mr. Brook, a fragment of which is represented by Plate IX., Fig. 4, of the coloured series. The living tints are, as there shown, a brilliant grass-green, with whitish terminal corallites. It has, so far, been collected only from a depth of two or three fathoms, and with the aid of native divers. From the neighbourhood of the Claremont and also the Piper Lightships, some excellent quantities of sponges belonging to the honeycomb, Hippospongia, and so-called finest Turkish, Euspongia, generic, types have been obtained. This subject will receive attention in another chapter.

The Forbes, Sir Everard Home, and Sir Charles Hardy, groups, all within a twenty-mile radius of Cape Grenville, are the chief islands of primary-rock formation north of the Flinders' group, in the sectional area now under notice. The largest of these islets, in the Forbes group, scarcely exceeds a mile in diameter, has a hill-summit 340 feet high, and is twenty miles from the mainland. The Sir Charles Hardy group includes three small islands located in the centre of the reef-area, almost due east of Cape Grenville; their highest point, on the northern islet, is 320 feet. The rock formation of this group is described by Jukes as "siliceous, hard, brittle, and of a brown colour; sometimes putting on the appearance of flinty slate, at others it seemed to be passing into porphyry, containing here and there crystals of red feldspar." In this respect their composition was found by Mr. Jukes to correspond precisely with the rocks of Cape Grenville. Among the smaller rocky islets worthy of notice in the present association, which commonly attract the attention of passengers by the coasting steamers, is one in the immediate neighbourhood of Restoration Island and Cape Direction, about latitude 12° 50″ S. Viewed from the north-east, it presents a remarkable resemblance to the semi-submerged head of an Egyptian sphinx, while, by a singular coincidence, the outlying flank of Cape Direction represents, in combination with it, the contour of a perfect pyramid.

In addition to the two gaps in the Barrier between Capes Melville and Grenville, already

mentioned, and distinguished as the First Three Mile Opening and Cook's Providential Channel, that of the Second Three Mile Opening occurs, almost midway between the two, in latitude 13° 5″ S. A very little farther north than Cape Grenville,—this promontory being utilised as the mainland landmark to steer for in association with it—the Raine Island entrance is arrived at. This passage, it will be recollected, was referred to in an early page of this chapter as the one formerly used most extensively by vessels bound from the south or the east for Torres Strait, and as the one which H.M.S. *Fly* was specially commissioned to survey and define more accurately. Raine Island and the immediate neighbourhood was, in consequence, made the head-quarters for some little time of the surveying staff; and Mr. Jukes, the naturalist and geologist to the expedition, made good use of the opportunity of examining and reporting upon its structure. An abstract of Mr. Jukes' original description of this island may be here reproduced.—

"Raine's Islet is about 1,000 yards long, by 500 wide, and in no part rises more than twenty feet above high-water mark. It is formed of a plateau of calcareous sandstone, which has a little cliff all round, four or five feet high, outside of which is a belt of loose sand, forming a low ridge between it and the sea. Some mounds of loose sand rest upon the stones, especially at its western end. The length of the island runs in about a N.N.W. and S.S.E. direction. It is surrounded by a coral-reef that is narrow on the lee side, but to windward, or towards the east, stretches out for nearly two miles. The surface of this reef is nearly all dry at low water, and its sides slope rapidly down to a depth of 150 or 200 fathoms. The island is covered with a low, scrubby vegetation, partly of reed-like and umbelliferous plants, and partly with a close green carpet of a plant with succulent leaves and stem, which we subsequently found was good to eat, and so went with us by the name of 'spinach.' The central part of the island had a rich black soil several inches deep, and here we commenced to dig a well, having brought pickaxe and spade, to try if we could find water. We dug about five feet deep, but found the rock too hard and tough to allow us to proceed further. The following was the section:—

	Feet.	Inches.
Good black vegetable mould	0	6
Stone, brown mottled with white, hard and coarse grained	0	3
Rich moist black soil, like bog earth	1	4
Stone of a light brown colour, rather soft but tough, and yielding slowly to the pickaxe	3	0
	5	1

"The stone was made up of small round grains, some of them apparently rolled bits of coral and shell, but many of them evidently concretionary, having concentric coats. It was not unlike some varieties of oolite in texture and appearance. It contained larger fragments of coral and shells, and some pebbles of pumice, and it yielded occasionally a fine sand that was not calcareous, and which was probably derived from the pumice. Some parts of it made

W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

ORGAN-PIPE-CORAL REEF, THURSDAY ISLAND, TORRES STRAITS.

a very fair building stone, but it got softer below, till it passed downwards into a coarser coral sand, unconsolidated and falling to pieces on being touched. In the quarries that were opened next year for the beacon, many recent shells, more or less perfect, were found compacted in the stone, and one or two nests of turtle eggs were discovered, of which in some cases only the internal cast had been preserved, but in others the shell remained in the form of white carbonate of lime. Some dusty cavities also were found in the stone, containing crystals of gypsum, or sulphate of lime. The presence of this mineral seems very odd, as I do not see whence the sulphuric acid could proceed. It is evident from the fossil turtle eggs that the consolidation of the stone had taken place after it was raised above the sea. It was due, probably, to the infiltration of the rain water percolating through the calcareous sand, that had been gradually piled above high-water mark by the combined action of the wind and waves. The thickness of the vegetable soil in its centre shows that it has been above water for a great length of time.

"The whole surface of the island was covered with old and young birds. These consisted of frigate-birds, boobies, gannets, noddies, and black and white terns, the only land birds being landrails. The frigate-birds had a small colony for themselves; their nests consisted of a platform about a foot high, in each of which was one young bird. There were young of all ages—some able to fly, others just hatched, and covered with yellowish-white down. Those which could not fly assumed a fierce aspect as we approached, and snapped their beaks at us. The boobies and gannets each formed separate flocks, but few of them had either eggs or young ones. All the rest of the island was covered with the eggs and young ones of the terns and noddies. The terns' eggs lay scattered about the ground without any nest, and how each bird found its own again among so many was a marvel to us. The young terns were also of all ages, some fluttering up into the air from under our feet, others just hatched. Each one seemed unalterably attached to the spot where it had been hatched, and immediately returned to it on being driven off. We had picked a clean spot on the sand, just on the top of the beach, for our bivouac; but there was one young tern there, a few days old, that we could not keep away from among our things, and the old one kept hovering and sailing and screaming, just above our heads, to look after it. The whole island stank like a foul hen-roost, and we were covered with bird-lice and ticks after sleeping in the sand. We dined upon young boobies and frigate-birds and terns' eggs—the latter were excellent, and the former very good, especially when cooked with a little curry powder. As night closed in, it was curious to see the long lines and flocks of birds streaming from all quarters of the horizon towards the island. The noise was incessant and tiresome. On walking rapidly into the centre of the island, countless myriads of birds rose shrieking on every side, so that the clangour was absolutely deafening, like the roar of some great cataract."

Raine Island has within recent years been turned to profitable commercial account. The

myriads of birds mentioned by Mr. Jukes, whose habits are so graphically described in the foregoing quotation, have accumulated, during the countless centuries in which they probably enjoyed unmolested occupation, and lived and bred there, a vast deposit of guano little inferior in quality and value to the far-famed Peruvian variety. The essential chemical difference between the two is that, whilst the Peruvian guano abounds in ammonia as well as in phosphates, that obtained from Raine Island is composed of phosphates only. The difference is accounted for by the fact that the guano imported from the South American coast-line is derived from a permanently arid and rainless district, whilst the site of the Raine Island accumulations is necessarily exposed to the heavy rainfall during the north-west monsoon. For many agricultural purposes this conservation of the pure phosphates only possesses advantages. Dealing with the subject of guanoes, it may be recorded that hopes originally ran high respecting the possible utilisation of the vast deposits of bat excreta in caves in the Rockhampton (Keppel Bay) district of Queensland, although to all appearance resembling guano of the highest class, it is found on analysis to be altogether destitute of phosphates, and has so far been turned to no practical account. Concerning the Raine Island guano, it may be observed that the deposits occur under three distinct conditions : Firstly, in layers some fifteen inches thick, immediately beneath the upper crust of coral conglomerate, which constitutes the encircling plateau described by Mr. Jukes; secondly, in pothole-like hollows in the same location; and thirdly, in trench-like depressions in the central black earth basin. The deposits are so extensive that the present proprietors have found it worth while to import a locomotive and all the plant requisite for tramways over which to convey the material to the landing jetty. The work of collecting and shipping the guano began in the year 1882, and the supplies are apparently far from being exhausted.

The birds that have been noticed in Raine Island, in addition to those mentioned in the list given by Mr. Jukes, include, as notified to the author by the present proprietor of the works, three white and one blue varieties of cranes, and a few stray pelicans. The main object of H.M.S *Fly's* first visit to Raine Island, 1843, was the charting of the passage, through the Barrier at this point, that was most frequently followed by vessels bound for Torres Strait. The undertaking was accomplished. The subsequent year the *Fly* repaired thither again for the purpose of erecting a substantial and conspicuous beacon on the island, that should assist vessels in making a straight course for the passage from the outer ocean. The beacon was constructed of square blocks of coral concrete, quarried from the east end of the island, the lime for the mortar used being compounded on the spot by burning the large shells of Tridacna and Hippopus, which could be obtained in abundance from the reefs at low water. The general plan of the beacon, which is still standing, is that of a circular stone tower, forty feet high and thirty feet at the base, with walls five feet thick. Erected on the highest ground of the island, its summit is fully seventy feet above low-water mark. This Raine Island beacon was, unfortunately, not destined to fulfil

so universally useful a mission as was originally anticipated. The intricacies of the navigation among the reefs, between the passage and the open channel near the mainland, occasioned so many wrecks and misadventures that the route was finally abandoned, by all but small craft, in favour of the much more open, although more remote, one known as the Great North-East or Blyth Channel, adjacent to the coast of New Guinea.

The comparatively short distance (a little over eighty nautical miles) between the parallels of Raine Island and Cape Grenville, and Cape York and Torres Strait, presents no special features, with the exception that the outer edge of the Barrier (following a course almost due north, and ultimately north-east, the trend of the land being north-west by north), while within forty miles of the coast abreast of Cape Grenville, is eighty miles from it opposite Cape York, the most northern point of Queensland, or, indeed, of the Australian Continent. The greater part of this area, exterior to the navigable coastal channel, is one intricate maze of coral-reefs, islets, and shoals, to a large extent unexplored, and marked on the Admiralty charts as "dangerous navigation." At several stages along the charted navigable route, north of Cape Melville, the steamers making for or hailing from Torres Strait are accustomed, unless it is particularly clear, to anchor for the night. The Cairn Cross Islands, a little coral group midway between Cape Grenville and Cape York, is one of these commonly chosen anchoring stations; and, if arrived at an hour or two before dusk, the opportunity of a brief run ashore is frequently afforded passengers. Such an opportunity occurred, and was utilised by the author, when on a voyage from Sydney to Port Darwin, by one of the China Navigation Company's ships, in the year 1888, and represented, in point of fact, his first practical acquaintance with a coral reef. On this occasion only a portion of the inshore, or upper, platform reef was uncovered by the tide; but to one to whom such a scene was entirely new the experience was absorbingly interesting. In the shallow pools or thin sheets of water just covering the reef, black Bêche-de-mer, *Holothuria atra*, and *H. coluber*, were extended in every direction, grasping sand and coral particles with their extended tentacles, which, being withdrawn, food-laden, were thrust, one after the other, into the circular mouths. Other varieties of Holothuria were found concealed under the broken slabs of reef-rock; and from the same coign of vantage might be seen protruding on every side the long spinous arms of a brittle starfish, apparently identical with *Ophiomastix annulosa*, represented by Chromo plate XI., Fig. 11. The arms of the starfish, which are five, are exceedingly flexible. Numerous extensive membranous suckers are developed from their central groove; and they thus constitute very efficient prehensile organs, which extend in a tentative manner in all directions, while the body remains concealed, and seize and convey to the mouth any suitable substances. The same shallow pools on the Cairn Cross reefs were thickly tenanted by a delicate, transparent, pink Synapta, from six to eight or ten inches long, when expanded, which were extended, and feeding in the same manner as the larger Holothuriæ. Chromo plate XII., Fig. 9, represents a group of Synaptæ of very similar

shape and size, but of more variable colours, that were dredged up in a tangled mass in Cleveland Bay, off Townsville.

The high-water bands of flotsam and jetsam on the Cairn Cross beach contained, as do many of those coral-islets in the Barrier district, thousands of the chambered spiral shells of the Belemnitoid genus Spirula. The habitat and natural conditions under which this interesting little cephalopod flourishes are among the unsolved mysteries of science. It was expected that the *Challenger* expedition would throw a flood of light on the life phenomena of the type. A single perfect specimen dredged off Banda, in 360 fathoms, and some dead shells collected, as at Cairn Cross, on the beach of Raine Island, recently described, and a single dead shell from a depth of 2,000 fathoms off the north coast of New Guinea, are the sum total of the material illustrative of the genus Spirula obtained throughout the cruise, as recorded in the excellent report on the Cephalopoda of the expedition, drawn up by Mr. W. E. Hoyle, Naturalist on the editorial staff of the *Challenger* reports. It is remarked by Mr. Hoyle that the single shell, dredged from 2,000 fathoms north of New Guinea, had a dead shell of a barnacle attached to it, and that this Spirula had almost certainly fallen from the surface of the sea to the depth at which it was taken.

A similar association of an originally floating fulcrum with an attached organism, distinguished a specimen found by the author on the Cairn Cross beach. This was represented by a rounded lump of pumice-stone, about $3\frac{1}{2}$ inches in diameter, to which two young coralla of the Madrepore, *Pocillopora damicornis*, were attached. The bases of the coralla are each about $1\frac{1}{2}$ inch wide, and the rudimentary tuberculate branchlets are about $\frac{3}{4}$ of an inch high. This specimen was thrown on the beach in a buoyant condition, as is evident by its still floating lightly even in fresh water. The attached Pocilloporæ probably represent the growth of a few months only, and would, at an early date, have completely invested the pumice-stone fulcrum, and caused it to sink. Dredged up from deep water in a perfect, if dead, condition, this typical reef-coral, with the concealed pumice nucleus, would have proved a very apple of discord among biologists. In the condition in which it was found, the specimen throws a new light on the means of reef-coral distribution. The two attached coralla indicate the probability of coral-germs floating abundantly at the surface of the sea, and that by attaching themselves freely to such objects as floating pumice they may be distributed through the most widely-extended areas. The sudden and otherwise inexplicable disappearance of tracts of floating pumice from districts where they have previously abounded, may be also easily accounted for by the attachment of coral or other organic germs. Evidence was elicited by the author, in connection with the specimen now under discussion, from a resident in Borneo, that the pumice-stone ejected during the eruption of Krakatoa, and distributed for thousands of square miles, disappeared within a short time over extensive areas through the abundant attachment of a species of barnacle to the floating masses.

One of the strongest attractions to ordinary passengers favoured with an opportunity of

landing on the Cairn Cross, Howick, or other of the numerous coral-islet groups scattered along the steamer route, is the chance of making a bag of the famous Torres Strait pigeons, *Myristicivora spilorrhoa*, a large white variety, highly esteemed for the table, which, arriving from the north, is distributed from October until the end of March throughout the tree-bearing islets and mainland coast as far south as Keppel Bay. The nests of this pigeon are usually built in the forked-branches of the mangrove and tee trees, that form such extensive thickets along the coast-line, and each contains two white eggs. A novel spectacle to the European traveller landing on these islands may probably be afforded by his first acquaintance with the nests of the Australian jungle fowl or scrub hen, *Megapodius tumulus*. These consist of huge mounds of dead leaves, grass, sticks, mould, and shells, scratched together by the adult birds in a well-shaded and sheltered situation among the Hibiscus or other bushes. The dimensions of the nest-mounds may be as much as twenty feet or more in diameter, and from ten to fifteen high, several pairs of birds commonly joining in their construction. When the mounds are completed, the birds burrow holes in the centre of them and deposit their eggs, which are then left to hatch by the moist heat ingendered by the decaying vegetation. As many as forty or fifty eggs, usually of a brown or brick-red colour, as large as those of a turkey, are sometimes found in the largest mainland nests. The eggs, as well as the parent birds, are excellent eating. An attractively plumaged bird, very plentiful in Cairn Cross and on other of the northern Barrier islets, is the Australian bee-eater, *Merops ornatus*. Mr. A. R. Wallace, writing of this bird in his "Malay Archipelago," says :—

"This elegant little bird sits on twigs in open places, gazing eagerly around, and darting off at intervals to seize some insect which it sees flying near, returning afterwards to the same twig to swallow it. Its long, sharp, curved bill, the two long narrow feathers in its tail, its beautiful green plumage, varied with rich brown and black, and vivid blue on the throat, render it one of the most graceful and interesting objects a naturalist can see for the first time."

With Cape York, situated in lat. 10° 40″ S., Queensland and the Australian Continent reaches its most northern limit. The outer edge of the Barrier, although now much more irregular and disjointed, together with the extensive reefs of its interior system, are continued considerably farther. The last link in the chain of reefs that forms the outer wall of the Barrier, and that has now been followed for over twelve hundred miles, is located on the south side of Flinders' Entrance, in latitude 9° 40″ S. The centrally-developed, widely-expanding Warrior reef, which, with the single break of Moon Passage, is thirty-five miles long, reaches to within ten miles of the New Guinea coast, in lat. 9° 15″. The important Torres Strait group of islands, mostly of considerable elevation, and identical in their rock-composition with the strata of Cape York peninsula, constitute practically the western boundary of the Great Barrier area in this region, in the same manner as the mainland coast represents its limits farther south. The

number of islands in this Torres Strait group is about twelve; and, with the surrounding and intervening shoals and reefs, they stretch due north just half-way across the Strait. Prince of Wales Island (native name, "Muralug"), the largest of the group, is irregularly circular, about twelve miles in diameter; and its highest hill is 761 feet. Banks Island, "Moa," a little over twenty miles farther north, is nearly as large as Prince of Wales Island. All the rest are considerably less. Thursday Island, or "Waibĕn," with Port Kennedy, the headquarters of the Torres Strait pearl-shell fishery, and port of call and coasting station for the ocean steamers passing to or from India and China ports, although geographically one of the smallest islands of the group, necessarily takes precedence for commercial importance and activity.

The smallness of Thursday Island becomes apparent on seeking for it in the accompanying replica of the Admiralty Chart. Its name is not entered on the chart; but it is represented by the small speck, corresponding in size with the full-stop, in the adjacent name of C. York, that may be found close to the extreme north point of Prince of Wales' Island, which is itself the centre of three other islands of more considerable dimensions. The largest, Horn Island, or "Nărupai," is broadly ovate, and lies due east. Immediately north of it is Hammond Island, "Keriri," of narrow elongate form, its axis running north-east and south-west, while on the west side is located Friday Island, "Gialŭg," of scarcely larger dimensions than Thursday Island. Although none of the names is entered on the chart, the islands that bear them can be easily localised from the foregoing explanation. The high character of the land in Prince of Wales' Island, the largest of the group now under consideration, is clearly indicated in the reef-view reproduced in Plate II. of the Photographic series, in which the north shore of that island, with its scattered pearl-shelling stations, forms a prominent feature of the background.

The population of the Thursday Island district, including the several adjacent islands above enumerated, numbered last census a little less than 3,000, out of which no fewer than 1,600 find employment in the pearl-shell and the bêche-de-mer fishing industries. The number of nationalities included in this by no means very extensive population is probably in excess, comparatively, of what is to be found in any other quarter of the globe. Their names, as recorded in the annual report drawn up by the acting Government resident, Mr. Hugh Milman, for the year 1888, are as follows:—

English	Norwegian	Burmese
Scotch	Russian	Javanese
Irish	Natives of Australia	Egyptian
German	Brazilian	Africans
French	West Indian	Cingalese
Bengalese	Manillamen	Mauritius
Danes	Malays	Kanakas
Italians	Chinese	Japanese

That list was compiled, it is worthy of remark, from the Thursday Island (Port Kennedy) gaol books for a single year. Concerning the residuum of nationalities whose more retiring dispositions precluded their registration in the public archives, history is silent. The material progress of Thursday Island is assured by the fact that it has been determined to make it a fortified station and military depôt. The construction of the fort is in rapid progress. At the time of the author's last visit to the island (1891), it had already advanced so far on the path of luxury as to be the possessor of a hackney carriage.

All of the islands of the Torres Strait group are more or less begirt with fringing coral-reefs, while innumerable independent reefs of every shape and size prove a bar to bee-line navigation in the intervening channels. The characteristic aspects of the reefs skirting the shores of Thursday Island, and of others in the immediate neighbourhood, are extensively illustrated in this volume. Reference may be made to the Photo-mezzotype plates Nos. II., III., IV. B, XVIII., XIX., and XX. A and B. An illustration of the most northerly Warrior reef is photographically represented by Plate XI. The more conspicuous features of those various reefs, together with their coral products, is fully discussed in Chapter I.

As a centre for collecting and investigating the corals and the other marine products of Torres Strait, Thursday Island possesses incomparable advantages, and its special appropriateness for the establishment of a tropical biological station will be found advocated on a later page. The most considerable collection of corals representative of the Torres Strait area collected by the author, and contributed to the National Natural History Museum, were obtained from the neighbourhood of Thursday Island. The Warrior Island reefs, to the extreme north, also proved a very productive collecting-ground, while on the opposite, or south, side of the Strait, the Albany Pass, with the reefs around Adolphus and Albany Islands, were profitably explored. The majority of the Mushroom corals, Fungiæ, and species of Stinging Anemone, *Actinodendron* sp., illustrated in Plates XXII. to XXIV., were, as notified in the descriptive texts, obtained from this neighbourhood. The reefs around the more remote Murray and Darnly Islands, situated in the extreme north-east of the Barrier area, in the neighbourhood of Flinders' Entrance, yielded a coral fauna closely akin to that of Thursday Island, the genus Euphyllia, illustrated by Chromo plate IV., as at all the other stations explored in Torres Strait, being conspicuously represented. Large flats of the Zostera-like sea-grass *Posidonia australis*, upon which the Dugong habitually feeds, form a characteristic feature of the Murray Island foreshore. These Posidonia beds abounded with the small banded sea-snake, apparently *Chersydrus granulatus*, which is reported to be highly venomous. The natives of the island give the snakes a wide berth; but it is noteworthy that the European pearl-shell divers handle them with impunity, and the author, while ignorant of their evil reputation, has handled them without their attempting to bite. That they possess poison fangs, which they are, fortunately, slow to use, is established.

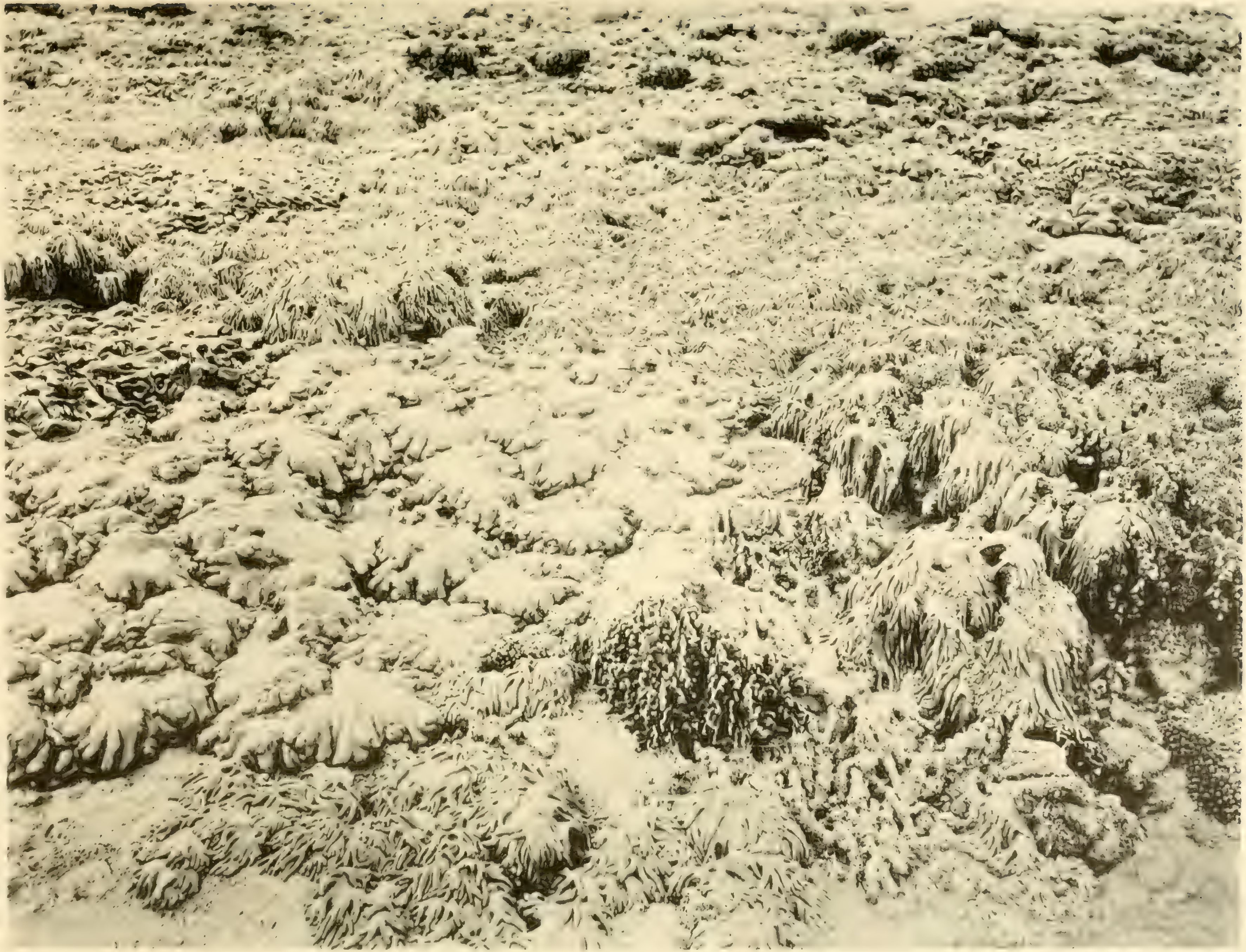
Both Murray and Darnly Islands, and also the small, more northern, islet of Bramble Bay,

all situated, as marked on the chart, on the extreme north-east area of the Great Barrier region, are composed, as originally described by Mr. Jukes, of rock formations that differ essentially in character from those of the Australian mainland, with the islands north and east of Cape York. In place of the granite and the feldspar which predominate on the mainland, the rocks of those north-eastern islands are explained by Mr. Jukes to consist partly of sandstone and conglomerate made of pebbles, or of lava and coral limestone, with some beds of finer tuff, and partly of large masses of dark, heavy, hornblendic lava. The eruption of these volcanic rocks, Mr. Jukes adds, "though probably of comparatively modern origin, geologically speaking, must yet historically be, of ancient date, as no traces of any craters are apparent. From the occurrence of pebbles of coral limestone, they are almost certainly of subsequent origin to the commencement of the coral-reefs here, but may yet date back into some tertiary period." Geologically, this Murray and Darnly Island group would appear to have a much closer connection with New Guinea, to whose shores they are relatively near. The physical appearance of these islands is also much more Papuan; the coastal areas, and often a large portion of the hills, being similarly covered with dense groves of cocoa-nut palms, which are not found on the Australian mainland and its more nearly associated islands.

The ethnological investigation of the Torres Strait region has revealed the fact that very marked distinctions characterise the racial affinities of the inhabitants of the eastern and the western sub-divisions of the Torres Strait areas; collectively, they are both physically and mentally vastly superior to the aboriginal tribes of the Australian mainland, and in this direction also possess much more in common with the Malay and the Papuan races. This subject has within the past few years been specially investigated by Professor A. C. Haddon, of the Royal College of Science, Dublin, who spent a considerable time in the Strait amassing information concerning their racial distinctions, customs, ceremonies, superstitions, and legendary traditions. Before the advancing tide of colonisation, these island tribes have almost entirely lost their original individuality. In many instances, in fact, the tribes as separate entities are virtually extinct, and, under the most favourable conditions, are now represented by a dwindling population, of which the name only will be left a few decades hence. Professor Haddon has, in consequence, rendered valuable service to the science of ethnology, in gathering together and rescuing from oblivion a trustworthy record of the individual distinctions and affinities of these island tribes.*

There is one other subject associated with the geographical aspect of the Great Barrier Reef that demands brief attention before proceeding to a consideration of the conditions under

* Readers desiring full information on this highly-interesting subject are referred to Professor A. C. Haddon's original paper, "On the Ethnography of the Western Tribe of Torres Strait," published in the Journal of the Anthropological Institute for February, 1890; also to his papers, entitled, "Legends from Torres Strait," published in Volume I., Nos. 1 and 2, 1890, of the journal *Folk-Lore*.



W. Saville-Kent, Photo.

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ALCYONARIAN REEF, THURSDAY ISLAND, No. 1.

which it probably originated. No mention was made, while tracing its course from its beginning, a little north of Sandy Cape, of the few isolated islets and detached reefs that occur at more or less remote distances from its outer border. The Portlock reefs, lying some thirty miles to the north-east of the Flinders' Entrance, are the most northern group. The Boot reef and the so-called Eastern Fields are intersected by the parallel of 10° S., at distances of thirty and seventy miles from the Barrier outer margin.

With the exception of the somewhat ill-defined Ashmore reefs, ten miles south of the Boot reef and a little nearer to the Warrior, the chart is a blank until the neighbourhood of the Raine Island entrance. Within the area, embraced by thirty miles north and forty miles south of this point, the edge of the Barrier itself is broken up in such manner as to form a series of irregularly projecting prominences, and of reef-masses, that are completely separated by deep-water channels from the main body of the Barrier. The Great Detached reef that forms the outlying southern boundary to the Raine Island entrance is the most conspicuous. It is of an irregular elongate outline, about twelve miles long with an average of five miles wide, but with a projecting central loop on its weather, or eastern, side. With the exception of its lee, or northern side, it is bounded by a continuous mass of reef that encloses a lagoon of from twenty to thirty fathoms deep. The lee, or inner, side, from which entrance may be gained to the lagoon, is an irregular bank of soundings, with scattered reef patches growing on it. Between this Great Detached reef and the main body of the Barrier there is a channel five miles wide, throughout which a bottom of 105 and 135 fathoms were obtained at two isolated points during the *Fly's* survey. Six miles south of the Great Detached reef, and between three and four distant from the Barrier margin, is a second detached reef of irregularly circular outline, and about three miles in diameter, which is known as Yule's Detached reef. This reef, as first described by Mr. Jukes, "rises from an unknown depth greater than one hundred fathoms, and seems to have a deep lagoon in the centre into which there is no entrance." Special interest is attachable to these two detached reefs. They illustrate the existence of true atoll reefs in intimate association with the Great Barrier system in contradistinction to the atoll-like or false-atoll reefs exemplified by the separate elements of the Capricorn and the Bunker Island groups, within the southern area of the Barrier's border, referred to on a previous page.

The margin of the Great Barrier, immediately adjacent to Yule's Detached reef, is one of those irregular divergent projections from the almost rectilinear contour that most usually distinguishes its outer rampart. This projection, which is about ten miles long, describes a curve in a south-easterly direction; and, a similar crescent-shaped projection being developed towards its apex from a point a few miles farther south, in a north-easterly direction, they enclose, between them, an almost circular area, about twelve miles in diameter, which is known

as Wreck Bay. The depth in this bay was found by the *Fly* to be very great, no bottom being reached except close to the reefs. South of Raine Island Passage, the Osprey reef, with soundings around it of 1,300 and 1,400 fathoms, lies a little over seventy miles off the Barrier border, its southern edge being intersected by the parallel of 14° S. The Bougainville, Holmes, and Flora reefs, all of which include small areas that dry more or less at low tide—and a sand cay on Holmes reef, which is permanently elevated to a height of six feet,—are all located some eighty miles to sea, approximately, opposite the Trinity Opening. The Flinders' reefs, a scattered patch thirty-five miles long and fifteen broad, enclosing an irregular lagoon-shaped area with soundings of from twenty-six to thirty-three fathoms, with a sandy bottom, is situated fifty miles south-east of the Holmes reefs, and at about sixty miles distance from the Barrier's edge.

Several reefs occur further seawards, occupying parallels of latitude that roughly correspond with those of the Holmes and Flinders' reefs,—*i.e.*, 16° to 18° S. They include the Willis group, Coringa Island, the Magdelaine and Herald Cays, Tregrosse and Diamond Islets, and Lihou reef and cays. The last-named group of combined reefs and sand cays forms an elongate atoll-shaped chain, sixty-five miles long by about twelve in width, its long axis having a north-east and south-west direction. Its nearest distance from the Barrier margin is as much as one hundred and forty miles. The latitude of 19° S. intersects the northern edge of Marion reef, having a pear-shaped contour, and a length of about twenty-five miles, with its wider, obtuse, end directed north-east by east; its distance from the Barrier margin is about eighty-five miles. Along the Barrier farther south, no other independent group of reefs occurs within a moderate distance of its outer edge until the latitude of the inner Barrier (Swain reefs) series is arrived at, in about 22° S. Here the detached series of reefs and cays collectively known by the title of Saumarez reef occur at a distance of eighteen miles only from the outer border of the Barrier. Like the Marion reef, it is pyriform in contour and twenty-five miles in length, but with its broadest end directed towards the Barrier. It has a well-defined lagoon, with depths of from fourteen to twenty-seven fathoms, while immediately outside its rim the shallowest soundings are from 150 to 190 fathoms, but more often charted with no bottom at 200 fathoms. In addition to the detached reefs now enumerated, which occupy a position sufficiently near to the Great Barrier to be incorporated within its geographical radius, there are a few others, more notably opposite its southern moiety, that, standing out farther seawards, form, as it were, points of connection with New Caledonia and the more remote islands of the Pacific. Notably mention may be made of the Avon Islands, in latitude 20° S., 350 miles distant from the Great Barrier, and but 300 from the north end of New Caledonia. Farther south, the groups of the Mellish, Frederick, Wreck, and Bellona reefs occupy similarly isolated positions at varying distances, ranging from two to four hundred miles from the Great Barrier's edge.

The point is now arrived at when, following upon a brief descriptive summary of the physical features of the Great Barrier Reef, attention may be directed to the evidence throwing light upon the telluric conditions under which this vast coral rampart was originally fabricated.

As shown in the accompanying map, and made manifest in the foregoing descriptive narration, the Great Barrier Reef, throughout its extent, follows, more or less closely, all the sinuosities of the intra-tropical north-east coast-line of Australia, and is concurrent in the extreme north with the shallow soundings of Torres Strait. Its most prominent factors have been shown to consist of a long linear chain of reefs, that constitutes its eastern boundary, outside whose limits water over 100 fathoms deep is immediately reached. The distance of the outer margin of the Barrier from the mainland has been found to vary from as little as ten or twelve miles, at certain isolated points, to as much as ninety miles off Cape York, in the extreme north, and to 160 in the vicinity of Swain's Reefs, in the extreme south. Its average distance from the mainland, however, through the greater portion of its length, is from twenty to thirty miles. The area enclosed within the outer boundary of the Barrier includes a navigable lagoon channel, with an average depth of from fifteen to thirty fathoms. The remaining very extensive superficies is for the most part occupied with coral islets, and with shoals and reefs of every conceivable shape and size. Scattered among them are a few islands of higher elevation, and compounded of the same granitic or bed-rock formation, as the strata of the mainland.

A few reefs and cays, with surrounding depths of over 500 fathoms, occur at more or less remote distances from the Barrier's outer border; they, for the most part, exhibit an atoll-like plan of construction. Well-defined channels and passages interrupt the continuity of the Barrier at a few irregular intervals. The most conspicuous of these are associated with its southern moiety, and are opposite to, though at very considerable distances from, important river estuaries.

Although no direct evidence has been adduced to indicate that the Great Barrier Reef of Australia originated under those movements of subsidence, claimed by Mr. Darwin for the formation of barrier reefs in general, it has, up to within a recent date, been tacitly conceded that the structure now under consideration could have come into existence under no other more logically explicable conditions. Mr. Jukes sought diligently, in the earlier days of the Barrier's survey, for any positive evidence of a motion of upheaval. The huge blocks of coral rock lodging near the outer margin of the Barrier a little north of Raine Island, referred to on another page, and the observed phenomenon of pumice-stone cast up on mainland beaches, in various localities, many feet above the normal limits of the tide, are the most substantial testimony that he could bring forward. In the former instance, however, there can be little or no doubt that the rock-masses he described, are of the same storm-

stranded nature as those represented in Plate XXX. of this volume, and the intrinsic lightness of the pumice-stone would allow of its being blown during a hurricane, with the ocean foam, far above high-water mark. The small significance which Mr. Jukes himself attached to this evidence is made manifest in his final verdict concerning the Barrier's origin. In this he explicitly states: "I tried hard to find any substantial objection to this [Mr. Darwin's] hypothesis, and must confess I failed to do so. After seeing much of the Great Barrier reefs, and reflecting upon them, and trying if it were possible, by any means, to evade the conclusions to which Mr. Darwin has come, I cannot help adding that his hypothesis is perfectly satisfactory to my mind, and rises beyond a mere hypothesis into the true theory of coral-reefs."

Some attention was recently given to this subject by Professor A. C. Haddon during his sojourn in Torres Strait, but, as recorded in a paper on the geology of the district,* without his discovering any tangible evidence indicating a movement of upheaval. The author has been on the outlook for such testimony, during several years' investigation of this region, but with negative results, so far as evidence indicating any extensive upward movement was concerned. These investigations, nevertheless, elicited testimony indicative, apparently, of a slight local elevation of the coast-line in certain well-defined areas. This evidence, which was originally embodied by the author in his presidential address to the Royal Society of Queensland, for the year 1890, is here reprinted verbatim.—

"At many stations throughout the Barrier region, the circumstance may be noted that large expanses of dead coral intervene between high-water mark and the living banks. The dead coral here referred to, is not the broken *débris* that has been cast up by storms, such as commonly exists all along extreme high-water mark, but occurs at a lower level, *in situ*, as it originally grew, and lacks vitality only, to distinguish it from the growing reefs. The Albany Pass, between Cape York and Albany Island, yields a prominent illustration of this phenomenon. On either side of the passage there is a fringing coral-reef, the living inner margin of which, composed chiefly of a branching Madrepora, *M. millepora*, is only exposed at the lowest spring-tides. Immediately adjoining this living bank, between it and the foreshore, there is a belt of the same species of coral, but entirely dead, and brittle, like rotten ice, to walk upon. Within a few more years, this dead belt will no doubt be broken up, by the action of the waves and chemical disintegration, and be added to the existing inshore area of coral mud and *débris*. An examination of the circumstances that have brought about the present condition of the reef, show that this dead belt of coral is now exposed to atmospheric influences which are antagonistic to its growth, with every ordinary spring-tide; while the living coral, as before observed, is only visible above the water at the exceptional or lowest springs. At such period as the inner belt of dead Madrepora was alive, and that from its state of preservation cannot have been long ago, it must have grown at a similar lower level

* Prof. A. C. Haddon, "Notes on the Geology of Torres Straits." Report British Association, p. 587, 1889.

to that now living; and nothing but the general upheaval of the area on which it throve can logically explain the fact of its decadence. The fringing reef off Magnetic Island, near Townsville, presents closely analogous phenomena. Dead bivalve shells of large size, such as *Tridacnas* and *Pinnas*, also occupy their original positions here, in close contiguity to the dead corals. Further substantial evidence of slight upheaval in this district was afforded by a station-holder on Magnetic Island, and by whom I was informed that, within the time he had been located there, a very perceptible change had taken place in the small bay facing his property. In former years boats could approach the landing place at all tides, excepting very low springs, whereas now it was not possible to bring a boat in, at even ordinary low tide. The shallowing of the water could not be accounted for by the silting-up of the bay, there being no fresh water flow into it, while the rocky bed of the bay itself had apparently been raised to a higher level."

It is difficult to associate the phenomena described in the foregoing record with any other than a movement of upheaval; but, accepting this as proven, and premising for the nonce that the whole length and breadth of the Barrier region exhibited a similar testimony of emergence, the amount raised, a foot or two only, would be as nothing compared with the latitude of movement in one direction or the other that is required to account for the construction of the Barrier's mass. Had the Great Barrier been fashioned during a prolonged epoch of upheaval, substantial evidence of such movement would be yielded by the strata of the seaboard which it skirts; but of this there is virtually none. The hypothesis that originated with Mr. Darwin, and received endorsement at the hands of Mr. Jukes, that this famous reef, in company with others of its kind, must have been built up during a prolonged period of subsidence, has up to a very recent date been accepted without demur, and so far as it applies to the great Barrier individually, is propounded, as an elementary axiom, in the leading Australian handbooks.

In the face, however, of Dr. Murray's indictment of the subsidence theory, fully reported in the preceding chapter (see pp. 83, *et seq.*), and having regard more particularly to his uncompromising dictum (London Institution Lecture, *Nature*, Feb. 28, 1889)—"it seems impossible, with our present knowledge, to admit that atolls or barrier reefs have *ever* been developed after the manner indicated by Mr. Darwin,"—the compilers, doubtless, have already made provision for substituting the Murrayan interpretation in forthcoming editions. In this they will be well advised to "bide a wee." The Darwinian subsidence theory is by no means utterly defunct, and, from within the borders of the Great Barrier Reef and its environments, may yet receive the increment of direct evidence that is needed to rehabilitate it on a more substantial basis than that upon which it was originally founded. Mr. Darwin himself, in his famous work, "Coral Reefs," ed. iii., p. 128, frankly admits that "direct proofs of a subsiding movement are hardly to be expected, and must ever be most difficult to obtain." Mr. Guppy, whose views and evidence in favour of the anti-subsidence theory have been quoted, makes use of an expression, in the substance of a controversial letter to *Nature*, Vol. XL.,

1889, to the effect that the arguments in favour of Mr. Darwin's hypothesis "nearly all hinge on assumptions that cannot be proved."

The Great Barrier Reef of Australia not having, so far, been cited as a direct witness, one way or the other, in the difference between Dr. Murray and Mr. Darwin, such evidence as it can be made to disclose is invested with special interest. The most extensive reef-formation of the Barrier class throughout the universe, it occupies a crucial position with relation to the controversy—that, in fact, let it be premised, of the last line of defence, or inmost citadel of the Darwinian subsidence theory; whence, should the case for the defendants be made good, the enemies' camp can be invaded and despoiled.

And now to our guns! Attention has been already drawn, pp. 110 and 111, to the fact that all of the few big breaches in the Barrier's outer rampart—to wit, the Trinity Opening, Flinders' Passage, and Capricorn and Curtis Channels—are opposite large estuaries, though at the present time too remote from them (thirty to sixty or eighty miles) to be influenced by their streams. Although seemingly an unprovable assumption, it is maintained that these breaches in the outer Barrier wall were once in close proximity to the mouths of the rivers, and, in fact, owe their origin to the restraining influence of fresh waters on the coral-growths. To substantiate this assumption we resort to a magazine of ammunition that, whilst near at hand, has hitherto been unbroached. What, it may be asked, is the logical significance of the following facts? In the equatorial island of New Guinea there are birds and mammals identical with, or most nearly related to, forms living on the North Australian (Queensland) mainland. The flightless Cassowary, *Casuarius*, among birds, is one of the most notable of these; but it is in the mammalian list that we find the most substantial evidence. The Spotted Cuscus, *Cuscus maculata*, of New Guinea and that of North Queensland are specifically identical; and the same may be said of the species of the so-called Native Cats, Dasyurus, and of the Ring-tailed Opossums, Pseudochirus. The interesting group of Tree Kangaroos, genus Dendrolagus, hitherto supposed to be confined to New Guinea, has recently been found to possess a Queensland species, *D. Lumholtzi*, while an ordinary Grass Kangaroo, genus Macropus, nearly allied to *M. major*, most abundantly found on the Australian Continent, is an inhabitant of New Guinea also. Several species of the Flying Opossums, genus Petaurus, and allied types, are represented both in New Guinea and throughout Australia; and the same formula of distribution applies to the slender-limbed Bandicoots, of the genus Perameles. The essentially Australian group of the Monotremata, including the Echidna and the Platypus, its only living members, is represented in New Guinea by a species originally referred to the first-named of these genera, but on account of certain anatomical differences associated with the separate generic title of Proechidna.*

* Readers wishing to pursue this most interesting subject are referred to that very admirable handbook, "Mammalia, Living and Extinct," by Professor (now Sir William) Flower, F.R.S., and Mr. R. Lydekker.

A. ALCYONARIAN REEF, THURSDAY ISLAND, No. 2.

W. Saville-Kent, Photo

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B. ALCYONARIAN REEF, THURSDAY ISLAND, No. 3.

The facts above related infallibly demonstrate that the countries of New Guinea and North Queensland were in former times connected. The very conspicuous racial distinctions between the human inhabitants of New Guinea, the Torres Strait Islands, and the Australian continent, indicate, notwithstanding the near affinities of the lower mammalia, that the separation of the districts must have been accomplished in prehistoric times, probably in a middle tertiary epoch. This separation, moreover, could not have been effected by any other telluric movement than that of subsidence, and this, as shown by the Admiralty charts, to an extent of at least six or seven fathoms. The restoration of the land to a higher level, by the few fathoms required to indicate the former continuity of New Guinea with Cape York Peninsula, would have the effect of reducing the depth of the lagoon, or Inner Route Channel, between the Barrier and the mainland from Cape Flattery northwards, to such an extent that this route would, in many portions of its course, be virtually impracticable. In the southern moiety of its area, where the large rivers previously mentioned join the sea, the depth of the water is so much greater, twenty to thirty fathoms and over, that the existing route would not be materially affected, while the mouths of the rivers would not be brought much nearer to the outer edge of the Barrier.

Repairing to the southern extremity of the Australian continent, we find a large detached island, Tasmania, or Van Diemen's Land, of inconsiderable size as seen in the general map of Australia, but actually as large as Ireland. This island is separated from the Australian mainland by Bass's Strait, having a width of one hundred and fifty miles, and a minimum depth of about forty fathoms. An examination of the fauna of Tasmania reveals the fact that it, too, notwithstanding its present isolated position, must in an historically ancient, but geologically comparatively recent, period, have formed an integral portion of the Australian mainland. The longer period that must have elapsed since the separation of Tasmania, as compared with New Guinea, from Australia, is a natural corollary of the greater depth of the intervening channel, and is supported by the following evidence concerning the present and the past conditions of the island and the continental faunas.

It is particularly noteworthy that the two unique carnivorous marsupials known as the Tasmanian Tiger or Wolf, *Thylacinus cynocephalus*, and the Tasmanian Devil, *Sarcophilus ursinus*, are found living at the present day only in the Island of Tasmania. Remains of animals generically identical with both of these types, but representing larger and more formidable species, occur as Pleistocene fossils on the Australian mainland. The majority of the marsupial forms are, however, still common to both the continental and the island faunas, or are represented by closely allied species. The ordinary (or Great) Kangaroo, *Macropus major;* the common Opossum, or Vulpine Phalanger, *Trichosurus vulpecula;* the Ring-tailed Opossums *Pseudochirus Cooki;* the Wallaby, *Macropus ruficollis;* and the Native Cat, *Dasyurus viverrinus*, are all represented both in Tasmania and on the mainland. Neither is there any substantial

distinction between the island and the continental individuals of those most interesting oviparous monotremes, the Duck-billed Platypus, *Ornithorhynchus anatinus*, and the so-called Australian Porcupine, Echidna, although in the last-named instance the colder climate of Tasmania has evolved a finer-spined but more hirsute race, distinguished as *E. aculeata*, var. *setosa*, while the remaining varieties are retained for the continental type. There are numerous other mammalia whose representatives are generically, but not specifically, identical on the northern and on the southern shores of Bass's Strait. These include the Wombat, represented in Tasmania by *Phascolomys ursinus*, and on the continent by two, if not three, distinct forms. The Rat- and Jerboa-Kangaroos, genera Hypsiprymnus and Bettongia, while represented by single species only in the island, number three or four distinct continental types. The fresh-water fauna of Tasmania exhibits similar evidence of original continuity with the fauna of the Australian continent. The so-called cucumber mullet of Tasmania, and Yarra herring of Victoria, *Prototroctes maræna*, is a species nearly allied to the European grayling, common to the rivers both of Tasmania and of Southern Australia; and the same remark applies to the almost unique fresh-water representative of the cod family, *Gadopsis marmoratus*, familiarly known to colonists as the Blackfish. The largest known fresh-water crustacean, *Astacopsis Franklini*, a species of fresh-water crayfish, which grows to a weight of eight or ten pounds, is confined to the northern rivers of Tasmania, its nearest ally on the mainland being a smaller and more roughly spinous form, distinguished by the technical name of *Astacopsis serratus*. The Ringarooma district of Tasmania possesses a huge species of earthworm, *Megascolides tasmanicus*, three or four feet long, and over an inch in diameter, which has a counterpart on the Australian continent. The "early bird" to devour this worm is represented on both sides of Bass's Strait by the Australian Ostrich, or Emeu, *Dromæus novæ-hollandiæ*. The Australian continent, as hereafter shown, produces vestiges of some still earlier birds, evidences that shed a most interesting light on the question of the original junction of Australia with other and yet more remote countries.

The evidence as to the close alliance between the faunas of Tasmania and of the Australian mainland is accepted by all geologists, as, in the case of New Guinea and of North Queensland, incontestable proof of a bygone continuity of the lands, and also of the present combined area having subsided to at least the depth of the water in the intervening Strait. Subsidence, as has been already shown, was contemporaneously progressing on the extreme north of Australia, and it may be reasonably assumed that the same movement operated throughout the eastern Australian seaboard. The reader, by referring to the accompanying chart of the Barrier region, and elevating in imagination the sea bottom by forty fathoms (the minimum depth of Bass's Strait) throughout the Great Barrier Inner Channel and reef area generally, will arrive at results suggestive of the configuration of the land at the time of the union of Australia and Tasmania. The Great Barrier, as a barrier, will be non-existent;

all the soundings inside its outer margin will be obliterated, through the uprising of the land; the mouths of the big rivers will discharge their water almost directly into the ocean; and coral-growths will exist under no other conditions than those of a small fringing reef.

The contention of Mr. Darwin and the supporters of the subsidence theory is that the initial condition of a barrier reef is a fringing reef which, by the slow subsidence of its foundation, the upward growth of the coral-masses, and the widening of its lagoon channel, becomes gradually separated from the land, and abuts externally on the deep water of the ocean. At such time as the shores of Tasmania and of Victoria were continuous, and Bass's Strait was a dry highway for the free passage and intermingling of the primitive marsupial populations, the Great Barrier must have been such a relatively insignificant fringing reef, and it must have built up a very considerable proportion of its present mass during the hollowing out of the channels of both the Bass and Torres Straits.

The foregoing geological evidence being trustworthy and true, the construction of the Great Barrier Reef of Australia under conditions of subsidence, and in accord with the original hypothesis of Mr. Darwin, is proved. Should further geological evidence be desired to prove that the marine areas on the southern and the eastern regions of Australia have undergone a vast movement of subsidence, it is ready to hand. Attention has been drawn by the accomplished naturalist, Mr. A. R. Wallace, in his well-known works, "The Geographical Distribution of Animals" and "Island Life," to the peculiarities of the New Zealand fauna and flora, which, in a hitherto almost inexplicable manner, indicates a bond of affinity with those of Australia. From the Australian continent, New Zealand is distant no less than 1,200 miles, and for the most part an abyssal ocean intervenes. The most striking affinity is between the wingless or Struthious birds, represented in New Zealand by four living species of Apteryx, the kiwis of the natives, and several recently extinct species of Dinornis or Moas. The last-named birds resembled the emeus and cassowaries of Australia, equalling or even excelling them in stature. The skeleton of one species, *Dinornis maximus*, contained in the British Natural History Museum, is, in its ordinary standing attitude, eleven feet high. There is abundant evidence of various species of the genus having existed until within a few years before the settlement in New Zealand of Europeans; this evidence includes the plentiful discovery of their remains in the native cooking places, and also of eggs, in some instances containing portions of the embryos.

An ingenious and satisfactory interpretation of the seeming anomaly of the near alliances has been advanced by Mr. Wallace in his "Island Life," ed. ii., p. 473. He shows, with the assistance of a map, which he has courteously permitted the author to reproduce, that a distinct, although narrow, bank of soundings, of less than 1,000 fathoms, hereafter referred to as "Wallace's bank," runs up from New Zealand in a north-westerly direction, embracing

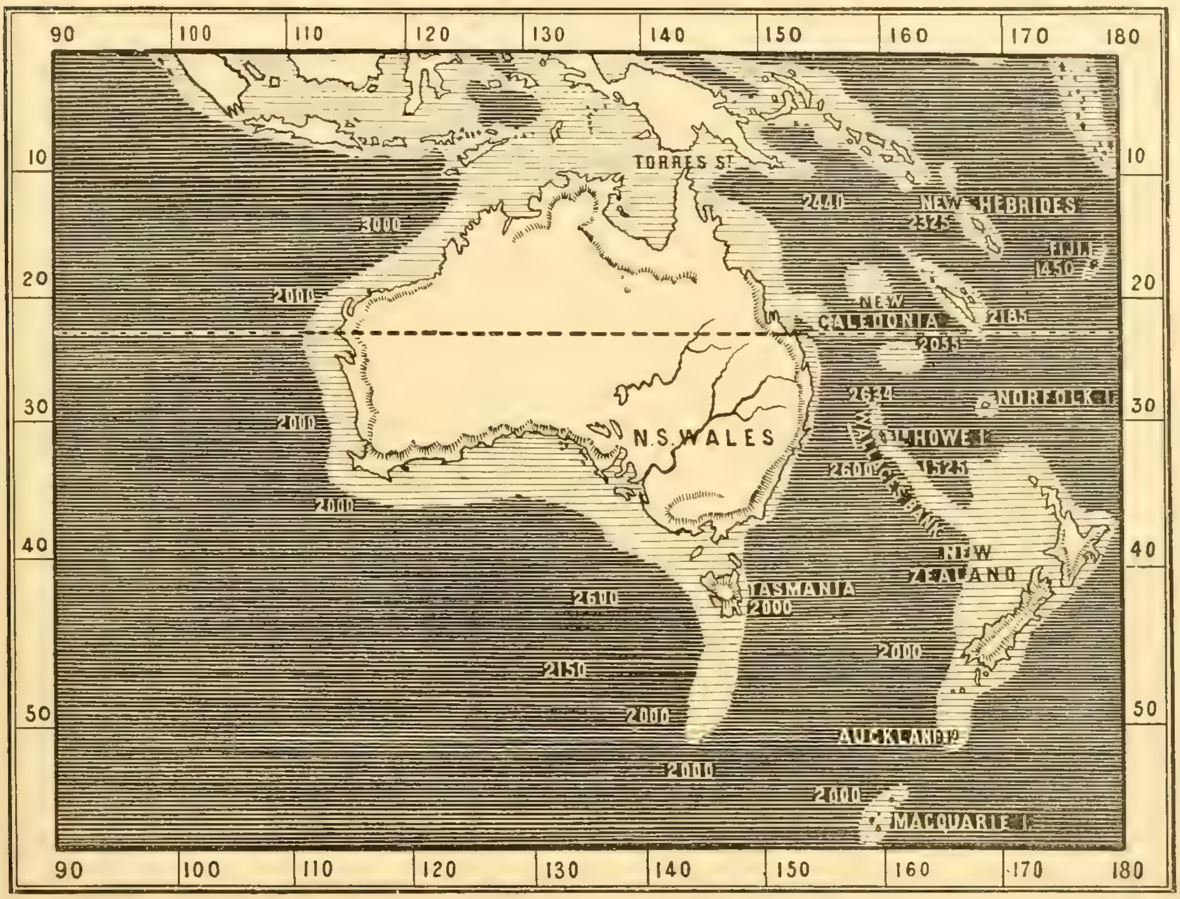
Lord Howe Island, and ending some three hundred miles off the Australian coast. In another work by Mr. Wallace, more recently seen by the author (the volume on "Australasia," in Stanford's *Compendium of Geography*), a more comprehensive chart shows that a more extensive bank, with soundings of less than 1,000 fathoms, completely unites New Zealand, *viâ* Norfolk Island and the Ballona and Bampton Shoals, with the Barrier Reef and Torres Strait. The presence of these shoal banks indicates, in Mr. Wallace's opinion, the former union of New Zealand with New Guinea and the north-eastern, or tropical, portion of the Australian continent. The affinities of many smaller New Zealand birds and plants support this interpretation, their alliances being conspicuously with tropical Australian and New Guinea types, rather than with temperate Australian species. Concerning the primeval union of New Zealand and the North Australian areas, Mr. Wallace distinctly indicates that this union must have obtained at a very remote period, and thus summarises his deductions.—

"The total absence (or extreme scarcity) of mammals in New Zealand obliges us to place its union with North Australia and New Guinea at a very remote epoch. We must either go back to a time when Australia itself had not received the ancestral forms of its present marsupials and monotremes, or we must suppose that the portion of Australia with which New Zealand was connected was then itself isolated from the mainland and was then without a mammalian population . . . We must on any supposition place the union very far back, to account for the total want of identity between the winged birds of New Zealand and those peculiar to Australia, and a similar want of accordance in the lizards, the fresh-water fishes, and the more important insect groups of the two countries. From what we know of the long geological duration of the generic types of these groups, we must certainly go back to the earlier portion of the tertiary period at least, in order that there should be such a complete disseverance as exists between the characteristic animals of the two countries; and we must further suppose that, since their separation, there has been no subsequent union, or sufficiently near approach, to allow of any important intermigration, even of winged birds, between them."

The author, through his recent residence in Queensland, has been in a position to draw Mr. Wallace's attention to additional evidence recently derived from the fossil deposits of that colony. This is no less than the discovery of remains of the nearest possible ally to the New Zealand Kiwi, Apteryx, in the Queensland (Darling Downs) deposits. The type, of which a few characteristic bones have so far been exhumed, has been described by Mr. C. W. De Vis, the curator of the Brisbane Museum, in the Proceedings of the Linnæan Society of New South Wales, Vol. VI., ser. 2, 1891, under the title of *Metapteryx bifrons*. This interesting discovery had been preceded by the identification of bones, obtained from the same deposit, of a species of Dinornis (generically identical with the New Zealand Moa), upon which Mr. De Vis has conferred the name of *Dinornis Queenslandiæ*. A third type, differing in certain peculiarities from Dinornis, has been associated with the separate generic title of *Dromornis*.

The deposits in the Darling Downs that have yielded these rich treasures are referred by Mr. De Vis to an epoch not later than early Pliocene.*

The foregoing record of the remarkable interblending affinities of the Queensland and the New Zealand avi-fauna, whilst seemingly, at first sight, a digression from the subject of



MAP SHOWING DEPTH OF SEA AROUND AUSTRALIA AND NEW ZEALAND. (AFTER DR. A. R. WALLACE.)

The light tint indicates a depth of less than 1,000 fathoms.

The dark tint indicates a depth of more than 1,000 fathoms.

the Great Barrier Coral Reef, is fraught, in relation to it, with far-reaching significance. To the author's mind, the moderate subsidence which brought about the separation between

* Readers who have followed the line of argument developed in the later pages of this chapter, will doubtless be struck by the singular identity of the New Zealand native name for this recently extinct Struthious bird, "Moa," and the aboriginal title of the island in Torres Strait now called Banks' Island. The coincidence—it may be nothing more—is remarkable.

Tasmania and the Australian mainland suffices to prove that this Barrier Reef originated, somewhere about the period of the later tertiaries, as a simple fringing-reef, and that it could have been produced by no other telluric conditions than those of prolonged *subsidence.* To minds dissatisfied as to the sufficiency of the bathymetrical subsidence to account for the building up of so vast a coral edifice, a blank cheque on Wallace's Bank of New Zealand, to be filled in to the amount of as many hundred fathoms, more or less, as they may elect to draw upon, is cheerfully conceded.

CHAPTER IV.

CORALS AND CORAL-ANIMALS.

CONCERNING the nature and organisation of the living animals by whose agency, direct and indirect, the vast edifice of the Great Barrier and all kindred coral-reefs are chiefly fabricated, much has been already said in the opening paragraphs of Chapter II. It was there distinctly demonstrated that the hard-dying, popular notion of an industrious coral insect that lived independently of the coral, and, with consummate skill and patience, built up the reef on the same principle as ants or bees construct their nests or waxen cells, had no foundation in fact, and should be permanently consigned to the limbo of exploded fallacies. It was also fully explained that coral-animals, in the restricted sense of the term, were organisms that agreed essentially in structure with ordinary polyps or sea-anemones, with the exception that they possessed the property of secreting within their tissues a distinct calcareous skeleton. It is proposed in this chapter to devote some space to a detailed account of the leading modifications of the innumerable species that are included by biologists in the coral-producing polyp class, associating such account with descriptions and illustrations of the more typical and attractive varieties which are comprised in the marine fauna of the Great Barrier Reef.

It is scarcely necessary, perhaps, to reiterate here that the main mass of the Great Barrier, and of all other coral-reefs, is chiefly composed, not of the perfect polyparies or coralla of growing corals, but of a sort of indurated concrete, built out of the broken-up and reconsolidated *débris* of coral-stocks that have either undergone natural disintegration, or have been forcibly torn by storms from their original position on the reefs. This indurated reef-rock, as previously remarked, may vary in texture from a fine, close-grained limestone, that rings under the hammer, to coarse, loosely-constructed conglomerate, in which coralla of every size and description, and every possible condition of conservation or of erosion, are bound together by a fine calcareous cement. Sufficient prominence, however, has not been previously given to the fact that the entire, or more or less fragmentary, calcareous skeletons of a large number of organisms, in addition to those of coral polyps, enter into the composition of the reef limestone or conglomerate. The class of the

mollusca, as abundantly represented on the reefs by the ponderous-shelled bivalves, Tridacna and Hippopus, the mother-of-pearl shells, oysters, and a host of other forms, contributes probably the most considerable portion of the supplementary lime supplies. The Echinodermata, including the several groups of the star-fishes, sea-urchins, and Holothuridæ or Bêche-de-mer, all of which are the possessors of more or less substantial calcareous skeletons, abound on every reef, and rank second, probably, to the mollusca as accessory lime contributors. The crustacæa, so called with relation to their indurated calcareous armour, are, as far as the larger species are concerned, conspicuously scarce among the reefs, not being represented even by the smaller species of crabs usually present in crowds upon ordinary rocky shores. The interpretation of this phenomenon, it is suggested, may be found in the fact that the crabs have no chance of establishing colonies on the coral-reefs, since their helpless larvæ or "Zoææ" would fall immediate victims to the extended tentacles and hungry mouths of the countless millions of polyps that clothe the entire superficies of the living areas. As an interesting commentary on his suggestion, a crustacean is hereafter described, and figured in Chromo plate II., whose chief abiding-place and citadel of refuge is within the mouth-portals of a huge anemone.

Of organic groups, other than those mentioned, which contribute their modicum of calcareous *débris* to the reef-mass, mention must be made of the Protozoic group of the Foraminifera, whose calcareous shells or tests, mostly of microscopic dimensions, are present in myriads on every reef and at every depth throughout the Barrier district. One special generic type, Orbitolites, represented by a flat discoidal test that is commonly from one-quarter to three-eighths of an inch in diameter, is so abundant among the reefs that it constitutes the chief mass of the material of the white so-called "sandy-patches" that intervene between the coral banks, and which is brought up adhering to the anchor-flukes by vessels halting for the night, as is customary, at stages in the more intricate northern moiety of the charted course. The shells or tests of this and other species of Foraminifera enter very extensively into the composition of the finer-grained coral-rock such as is represented by Plate XXXII., Fig. 5, wherein, in the original specimen, the embedded shells of Orbitolites and many smaller species can be readily detected with the aid of a magnifying glass.

There is also a small vegetable group, that furnishes a considerable quota towards the composition of the characteristic coral-rock. It is that of the peculiar seaweeds or lower algæ known as Corallines or Nullipores. They are distinguished by the encrustment of their tissues with carbonate of lime, to such density that their vegetable nature is completely disguised; and, excepting for the absence of the characteristic pores, they might in many instances be mistaken for the coralla of the Hydroid coral Millepora. These Nullipores, referable to the genus Melobesia, form either encrusting lichen-like expansions, irregularly nodulated, or short obtusely-branched growths, that often more or less completely cover the surfaces of the indurated coral-rock to a height considerably above that whereon Madreporaria are found growing. The colour

W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

GIANT ANEMONE, DISCOSOMA, SP., 2/3 NAT. SIZE.

of these rock-incrusting Nullipores being usually pink or lilac, they impart, where they are abundantly developed, a very characteristic feature to the reef-scape. In the deeper rock-pools, and on the sea-bottom generally, in the neighbourhood of the reefs, another generic form, Halimeda, belonging to the same Nullipore tribe, is locally abundant. This type forms erect, branching tufts, often several inches in length, of which the branchlets are composed of flattened, irregularly polygonal, or more or less fan-shaped, calcareous disks, strung together, as it were, in a moniliform or chain-like order. While growing, this Nullipore is a brilliant grass-green, but it bleaches, when dead, to a pure white. The bleached discoidal segments of its disintegrated fronds often occur in great abundance among the mixed calcareous components of reef-rocks and coral sand. A familiar representative of this Nullipore family that abounds on the British coast is known by the name of *Corallina officinalis*, so-called on account of its formerly supposed valuable medicinal properties. Its elegantly divided fern-like fronds are composed of slender, cylindrical, calcareous joints that vary through every shade of pink and lilac.

Before entering upon a detailed description of the organic class which constitutes the prime factor in the construction of all coral-reefs, a brief outline sketch of its leading modifications and limitations is desirable. The significance of all typical coral structures as the skeletal elements of animals, essentially identical in aspect and organisation with ordinary skeletonless polyps or sea-anemones, has been already indicated. Hence it is that all of the organisms, typified by the soft, askeletal, sea-anemones, and the skeleton- or coral-secreting polyps, that enter into the composition of the living coral-reef are associated together by naturalists into a single comprehensive animal group or sub-kingdom, upon which the title of the Cœlenterata has been conferred. The Cœlenterate, or polyp class, as, in non-technical language, it may be more conveniently termed, contains, moreover, an infinity of forms that, as it were, bridge over the hiatus between the solitary skeletonless sea-anemones and those polyps which in their myriads represent the chief agents in the building up of the massive reef. There are, in the first place, intermediate polyp species which, while not possessing a definite skeleton or "corallum," as it is technically termed, have their tissues so filled and strengthened with microscopic calcareous deposits or "spicules" that their substance is distinctly tough and coriaceous. This group is most prominently represented among the constituent elements of the coral-reef, by what are known as the Alcyonaria, having as their type in European seas the so-called "Dead-men's fingers," *Alcyonium digitatum*, commonly cast on the beach after storms, or obtainable with the dredge a little below low-water mark. The extent to which these Alcyonarian polyps enter into the composition of a living coral-reef is instructively illustrated by Plates XIX. and XX., wherein their flexible, leather-like, coralla occupy the bulk of the reef-scape and may cover an area of many acres. To a lesser degree, these Alcyonaria are represented in the greater number of the photographic reef-views that illustrate this volume. A noteworthy structural peculiarity of all the polyps

belonging to this group, or order, lies in the fact that the prehensile organs, or tentacles, which surround the mouth of each individual polyp are always eight in number, and have their edges fringed with secondary lobes or filaments ; in rarer instances, they are distinctly warted. In all ordinary sea-anemones and the more typical coral polyps the tentacles are a multiple of six. Very frequently they are only twelve, but more commonly from twice to five or six times that number. In the small group of the Antipatharia, as hereafter shown, the tentacles are usually as few as six. The individual tentacles, moreover, of all the coral-producing species, and of the majority of the skeletonless anemones as well, are perfectly simple. There are, however, exceptional forms of sea-anemones, or Actiniæ, in which the prehensile tentacles are of even more complex structure than those of the eight-rayed Alcyonaria.

The compound nature of the coral organisms which are most extensively associated with reef-construction has been already explained. Each of these compound growths, however, began its existence as a single individual polyp, and it is by a continual process of what is known as gemmation or budding—the new animal buds remaining in close union with the parent polyp, and, again, giving birth to successive buds—that the characteristic compound corallum is ultimately formed. The Mushroom-corals, genus *Fungia*, illustrate the more exceptional instances in which the coral polyps remain single in their fully matured condition. There are, on the other hand, certain exceptional forms of the skeletonless sea-anemones, or Actiniæ, which, through the continued adhesion of the buds, form more or less extensive composite communities. These exceptional types, hereafter enumerated, suffice to show that both the soft bodied anemones and the coral-forming series, embrace simple or individually distinct forms, in which the connection between parent and offspring is early lost, and compound or colonial ones, in which the connection is retained.

For the convenience of study and systematic classification, the entire series of polyp-animals or Cœlenterata, is subdivided into two primary classes and several subordinate groups or orders, whose most distinctive features are indicated in the following table.—

SUB-KINGDOM CŒLENTERATA, OR POLYP-ANIMALS.

CLASS I.—HYDROZOA, OR HYDROID POLYPS.

Including all Hydroid Zoophytes, most jelly-fishes, and a few coral-constructing species, Milleporidæ.

CLASS II.—ACTINOZOA.

Including all sea-anemones and true coral-constructing polyps; separable as a whole into the several following orders :—

ORDER I.—ACTINARIA.

Including all ordinary, isolated, sea-anemones.

ORDER II.—ZOANTHARIA.

Polyps resembling sea-anemones, but united so as to form composite colonies.

ORDER III.—MADREPORARIA.

Including all so-called "Stony-corals" and typical reef-constructing corals.

ORDER IV.—ANTIPATHARIA.

Polyps with six tentacles only, or a multiple of that number, secreting a dense horny or wood-like uniaxial or branching "sclerobase."

ORDER V.—ALCYONARIA.

Polyps possessing eight, usually pinnate, tentacles; either naked, associated with a fleshy corallum, or secreting a horny or spicular uniaxial sclerobasic corallum; the latter, though usually tree-like, is in some instances tubular.

ORDER I.—ACTINARIA.

The non-coral forming or skeletonless solitary Actinaria, popularly known by the familiar title of sea-anemones, occur in great variety among the reefs of the Great Barrier system, and are remarkable in some instances for their large dimensions, in others for their brilliant colours, and in a third series for the complex structure of their tentacles.

In working out the nomenclature and affinities of the Barrier Reef representatives of the Actinarian order, the author has received substantial assistance from Professor A. C. Haddon, of the Royal College of Science, Dublin, the author of several valuable monographs on the British Actiniæ. The authority named having also spent some months in Torres Strait, making the Actinaria, among other things, a subject of special study, is consequently familiar with the outward form and growth habits of a considerable number of the species described and illustrated in this volume. Professor Haddon and the author have, to a certain extent, "gone shares" in the division of the Actinozoarian spoils of the Torres Strait district, and, by mutual consent, have left to one another the nomenclature and description of conjointly collected species that proved to be new to science. In order to make the Barrier district catalogue of Actinaria as complete as possible, the names of all the forms met with by Professor Haddon that are distinct from the types collected by the author, are included in the list appended to this volume.

In chronicling the more remarkable varieties of the ordinary or simple sea-anemones indigenous to the Great Barrier Reef, attention may be appropriately directed, in the first instance, to certain giants of their race referable to the genus *Discosoma*. Two particularly large species of this genus occur in considerable abundance among the reefs as far south as Mackay, and are readily distinguished from one another by the character of their respective tentacles. In the one

species, illustrated by Chromo plate No. I., these tentacles are of the normal type, being simply subulate, cylindrical at their bases, and tapering off to a point at their distal extremities. In the second form, the species represented by Plate II. of the coloured series, the tentacles are distinctly capitate, or knobbed like drum-sticks at their distal ends; but when seen collectively they present superficially the appearance of closely crowded spheroidal beads. The first-named form, which is the larger, not unfrequently measures as much as two feet in diameter; it may be commonly seen extended to its fullest width in the shallow pools when the tide is down, or, in its half-contracted state, as a blubber-like mass, on the surface of the exposed reefs. The colours in this species are exceedingly variable, and correspond to a remarkable extent with those of the British Opelet Anemone, *Anemonia sulcata*, better known, probably, by its formerly familiar title of *Anthea cereus*. Thus, the most ordinarily occurring tints, of both the tentacles and the oral disk, are a light fawn or pinkish-brown hue, but in some instances the fawn-coloured tentacles are tipped with magenta. As in one variety of *Anthea cereus*, it not uncommonly happens that while the tentacle tips are coloured magenta, the basal portions of the tentacles, and the entire area of the oral and tentacular disk, are a pale sea-green. A more beautiful, but somewhat rarer, variety of this species occurs, in which all the tentacles are golden-brown at their bases and a rich royal blue throughout their distal halves. The intervening area of the oral and tentacular disk is reddish-brown, inclining in the neighbourhood of the mouth to orange-yellow. In some respects this huge anemone appears to agree with the Red Sea *Discosoma gigantea* of Forskål. Professor Haddon, however, who has collected this species in Torres Strait, and made careful dissections of it, is satisfied as to its structural distinction, and has paid the author the compliment of associating his name with its specific designation as *Discosoma Kenti*, in a paper generally descriptive of Torres Strait species, communicated to the Proceedings of the Royal Dublin Society. It was observed of this variety when fully extended and in complete repose, that the tentacular disk exhibits a tendency to pleat itself into six symmetrical folds, as illustrated in the upper figure of Chromo plate No. I.

In the second, or bead-tentacled species of Discosoma above referred to, an almost equal amount of colour variation obtains. In this type, the tentacles and oral disk commonly exhibit a mixture of shades. In one of the most ordinarily recurring varieties, the spheroidal bead-like tentacles occur in irregularly-mixed patches of grey, white, lilac, and emerald-green, the disk being shaded with tints of grey, while the oral orifice is bordered with bright yellow. An illustration of a segment of this characteristically-tinted variety is represented by the upper figure of Chromo plate No. II. The lower figure in the same plate depicts a segment of a rarer variety of this species, collected at Thursday Island. The oral centre in this example was yellow, the general surface of the tentacular disk fawn-brown, and all the bead-like tentacles were a brilliant apple-green. Although apparently not growing to quite such large dimensions as the preceding species, the diameter of from twelve to eighteen inches, to which it commonly attains, represents a by

no means insignificant size. A photographic illustration of this species, in addition to the coloured lithograph, is given in Plate XXI. of the photo-mezzotype series, in association with the description of which plate further details concerning this handsome species are recorded. As therein stated, the species being undoubtedly new to science, the author has conferred upon it the title of *Discosoma Haddoni.* In common with the preceding type, this fine Discosoma occurs abundantly among the reefs of the Great Barrier system, from Torres Strait southwards to Mackay.

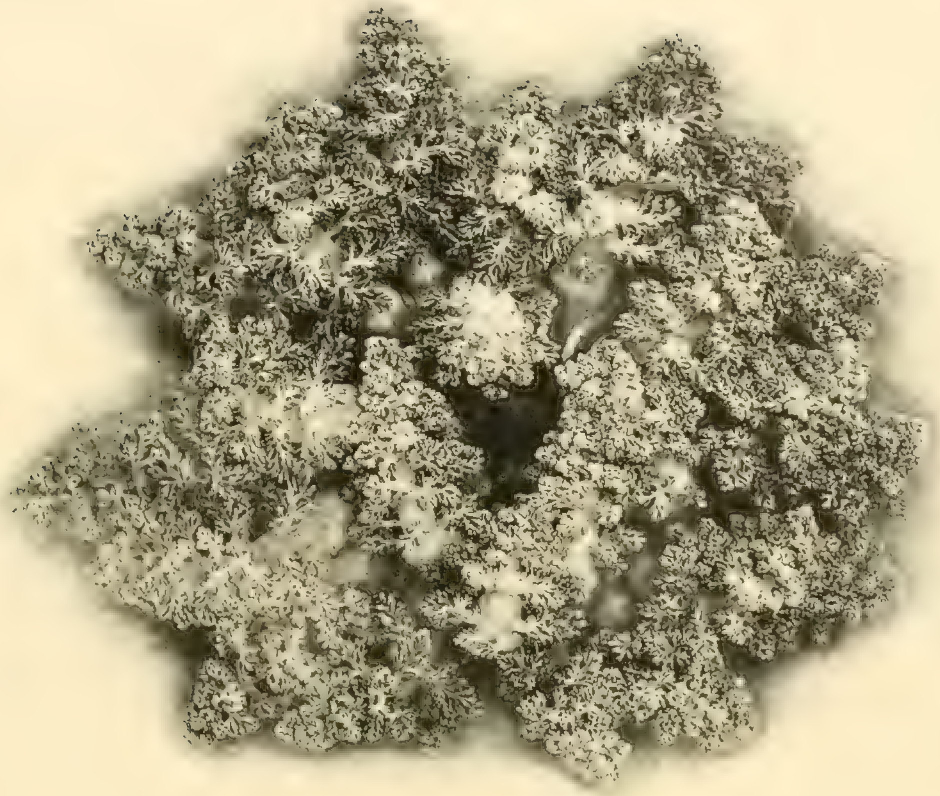
A phenomenon of high interest is associated with the two giant anemones just described. Both of them, in point of fact, act the part of hosts to other living organisms of appreciable size; the guests comprising two species of fish, and also a species of prawn. The larger species, *Discosoma Kenti,* almost invariably contains two or more specimens of a percoid fish about three inches long, that is identical with the *Amphiprion percula* of Lacepede. On thrusting a stick into the oral orifice of the anemone the fish swim out, but return immediately to their residence within the gastric cavity of their host on the removal of the disturbing missile. The fish thus furnished with free lodgings by the anemone is notable for its brilliant coloration. The ground colour in this type is a bright orange-vermilion, interrupted by three pearly-white cross-bands, which, as well as the edges of the fins, are bordered with black. A coloured representation of this species, characteristically illustrating the conspicuous colour contrast it makes with its adopted host, is included in Chromo plate No. I. The second species of fish, *Amphiprion bicinctus,* that similarly lodges with *Discosoma Haddoni,* but dines out, presents the same orange-vermilion ground colour, but possesses only two white cross-bands, and neither these nor the fins are edged with black. It is similarly illustrated in Chromo plate No. II. in close contiguity with its Actinarian host. In a third species of this genus, apparently identical with *Amphiprion melanopus,* collected by the author at Port Darwin, there is only one intersecting band of white, and as this crosses the fish's head and cheeks it communicates to it the ludicrous appearance of having its face bandaged as though for toothache. At first sight it was, as a matter of fact, imagined that a scrap of white paper was accidentally adhering to the fish, and it was only on attempting to remove it that it was recognised as forming an integral part of the organism.

An additional guest entertained by the bead-tentacled *Discosoma Haddoni* is a species of prawn about two inches long, apparently referable to the genus Palæmon, and also illustrated in Chromo plate No. II. It is remarkable that the dominant tints of this crustacean coincide with those of the fish Amphiprion, being white and red, although in this instance the darker colour is in abeyance. These corresponding, very conspicuous, colours in the separate commensal guests of the sea-anemones doubtless fulfil some important function in the vital economy of the associated organisms. What that function is it is difficult to tell; but, by way of a tentative guess, it might be suggested that the brilliant colours of the commensal guests attract the notice of other predatory fish, which, hastening to seize an apparently easy prey, are themselves entrapped within the outspread tentacles of the passively expectant sea-anemones. Their function under such conditions

would be parallel with that which has been supposed to subsist between the pilot fish and the shark ; the commensals, in return for shelter and protection from fiercer foes, fulfilling for their hosts the *rôle* of effective lures.

Among the sea-anemones of the Barrier district noteworthy for their beauty of structure rather than that of colour, two representatives of the respective genera Actinodendron and Megalactis invite special notice. In the members of the first-named genus the tentacles, or their arm-like homologues, are twenty-four in number, exceedingly long in comparison with the diameter of the disk, and ramified, after the manner of the fronds of many ferns or seaweeds, to a degree which is technically termed tripinnate or even bi-tripinnate. Their aspect when fully expanded in the sandy hollows among the coral-rocks, or in pools nearer inshore, so much resembles that of symmetrical tufts of growing seaweed that they may be easily mistaken for such vegetable organisms. They are, doubtless, innocently approached under such an impression, and to their own undoing, by the living animals on which they feed, which realise the fatal error they have committed too late to make good their retreat. The species under consideration, *Actinodendron alcyonoideum*, moreover, is noted for stinging properties which are nearly as severe as those of a nettle, while the rash raised by handling it, as experimentally tested by the author, lasts for about a week. In this type the stem or column, with its adhesive base, is usually rooted, to a depth of a foot or more beneath the sand, to a substratum of the solid coral-rock. The polyp is furthermore very difficult to detach intact, on account of the great fragility of the branching tentacles, which are apt to adhere to the hand and break up, piecemeal, in the attempt to root it up. Under these conditions it was found that the only effectual method of securing an unbroken crown of tentacles was to insert a long, sharp knife underneath the sand, and to then sever the column as near as possible to its adherent base. The illustration of this species given in Plate XXII., No. 1, of the photo-mezzotype series, is reproduced from a photograph taken of the anemone when expanded *in situ*, in a pool on the sandy flat adjacent to the fringing coral-reefs off Somerset, in the Albany Pass. Larger specimens not unfrequently occur which are twice the diameter of the example figured. Its colours in life are usually of a light stone-grey, the extreme tips of the minute tentacular ramifications being almost white.

The second species of branching-armed anemone represented by the lower of the two figures in the plate above quoted has more attenuate tentacles than those of the preceding type, while the ultimate ramifications are individually isolated and distinct. The oral disk in the fully expanded polyp shows much more clearly, and, together with the tentacles, exhibits a relatively elaborate colour pattern. As shown in the photograph from life also taken of this type, twelve white radiating lines, corresponding with the axes of the six primary and six secondary tentacular radii, and of distinct relative length, occupy the centre of the disk. Outside these, again, there are twenty-four shorter lines of even length (such as might make



No. 1. STINGING ANEMONE, ACTINODENDRON SP., NAT. SIZE.

W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

No. 2. STINGING ANEMONE, LONG-ARMED VARIETY. NAT. SIZE.

the primary subdivisions of a twenty-four hour timepiece) which correspond with the twenty-four inter-tentacular radii. These shorter lines are, in the photographic illustration, for the most part obscured by the basal ramifications of the tentacles. A consecutive series of five of them, however, are distinctly visible towards the upper right-hand corner. The basal halves of the main shafts of the tentacles in the example photographed were alternately of a pale lilac and pale sea-green hue, their ultimate ramifications, and also the ground tints of the coral disk, being represented by shades of grey and buff. Although occurring under similar conditions, this anemone does not, generally, root itself as firmly and deeply to underlying rocks as does the Actinodendron. It, moreover, does not possess the distinct urticating properties that obtain in its ally, and it may therefore be handled with impunity, or, as was the case with the specimen figured, be detached and transported without mutilation for leisurely observation. As explained in the mention of this anemone given in the descriptive account of Plate XXII., p. 35, it is referable to the genus Megalactis of Ehrenberg, while, as a new species of that genus, it is associated in this volume with the distinctive title of *Megalactis Griffithsi.*

The sea-anemones of the Great Barrier Reef district that are most remarkable for combined beauty of colour and structure are undoubtedly those referable to the genus Heterodactyla. In this group, the tentacles are for the most part plumose in character and developed in tufts, or in the form of a closely-set pile throughout the greater area of the surface of the expanded disk. Interspersed among the tentacles, and representing structural modifications of these organs, are clusters of spheroidal-shaped bodies that are remarkable for their jewel-like brilliancy. In the larger species of the genus, apparently identical with the Red Sea *Heterodactyla Hemprichii*, obtained from the Albany Pass, Torres Strait, and also from the Barrier Reef off Cape Flattery, the expanded disk is somewhat irregularly lobate and four or five inches in diameter. The short supporting stalk, or column, is pale pink, variegated with regularly developed longitudinal lines of carmine spots. The centre of the expanded disk, in the vicinity of the mouth, is a pale lemon-yellow, its peripheral border a light olive-brown, and the intermediate area a variegated mixture of both these tints. The tentacles in this species are more or less distinctly pinnate, developed singly or in interrupted rows near the centre of the disk, becoming more thickly massed as they approach the peripheral border. The tentacles appear superficially to be of a yellowish-brown hue, but, examined with a lens, they are found to be transparent lemon-yellow with a central olive-brown core, which is continued throughout the main shaft into their pinnules. The jewel-like clusters are developed only along the peripheral border of the disk; but, as seen isolated, they consist of tentacles so modified that in many cases the distal pinnules retain their normal character. In other instances, the same structural modification has so far progressed that the entire series of pinnules are replaced by the spheroidal organs.

These spheroidal berry-like clusters, in accordance with their chiefly containing urticating cells, or nematocysts, may be appropriately denominated "nematospheres." In the Torres Strait example, they were remarkably brilliant. With the exception of a small spot at its extreme apex, each was brilliant translucent violet; while its apical spot, by way of contrast, was the most vivid emerald-green. As viewed under a low power of the microscope, the clusters might be appropriately compared to currant-like fruit, carved out of amethyst, with a crystal of emerald inserted, to represent the cicatrix of the antecedent flower. These jewel clusters most frequently comprise five or six spherules only, and, in the most exceptional instances, are no larger in number than nine or ten. A coloured illustration, necessarily inadequate to represent the natural beauty of the expanded polyps, and also of the jewel-like "nematospheres," is included in Figs. 3 to 3D of Chromo plate No. III. In a second example of this species, collected on the Barrier Reef opposite Cape Flattery, small patches of the tentacles were entirely lemon-yellow; but in all other respects it corresponded with the specimen from Torres Strait. From the same locality on the Barrier Reef a third anemone was secured, which, while corresponding in its broader characters with the two already enumerated, differed from them so conspicuously in certain structural details, that there appeared to be sufficient grounds for its recognition as a distinct species. The tentacles in this example were a most brilliant grass-green, minutely subdivided, and so crowded together on the convoluted surface of the oral disk that they presented the aspect of aggregated tufts of fine, brightly-coloured moss, or, yet more appropriately, certain varieties of the very finely-divided leaves of cultivated parsley. A few small scattered groups of tentacles were observable a little within the general mass; but they did not occur as isolated units or in radiating lines as in the specimen previously referred to. The berry-like bodies, or nematospheres, formed considerably larger clusters in this type, commonly containing from twenty to thirty or more closely-aggregated spherules. The colour of these bodies differed from those of the preceding form in that they were a bright amethyst throughout, a somewhat darker tint of the same hue occupying the position of the emerald spot of the preceding type. The supporting stalk or column, and likewise the centre of the oral and tentacular disk, which is bare of tentacles to a relatively larger extent than obtains in the preceding species, was of a light stone-grey hue, with a tendency to a pale shade of green.

This species differs so distinctly, with regard more especially to the constitution of its groups of nematospheres, from the hitherto single known type, previously described, that it is necessary to confer on it an independent specific name. With reference to the moss-like aspect of its aggregated tentacles, it is herewith proposed to distinguish it by the title of *Heterodactyla hypnoides*. With respect to the coloured illustration of the species, given in Fig. 6 of Chromo plate No. III., it is desirable to remark that the groups of violet nematospheres, while apparently distributed indiscriminately over the surface of the disk, are actually, in all instances, near the edge of its voluminous,

closely-convoluted, border. A photograph, taken from life, of this individual specimen reveals a similar peculiarity of their disposition.

Among the Barrier Reef varieties of sea-anemones in which the tentacles are compound in structure, the form figured in Chromo plate III., Fig. 5, under the title of *Phymanthus muscosus* is, perhaps, the most abundantly represented. In the flattened shape of the tentacular disk, and in its habits of wedging its base in small holes or narrow crevices of the rocks, this anemone bears some resemblance to the British species *Sagartia (Heliactis) bellis*, familiarly known as the "Daisy Anemone." The expanded disk in this type measures three or four inches in diameter, and, excepting the relatively small central oral area, it is entirely concealed by the flattened, outwardly overlapping bipinnate tentacles. These tentacles in mature polyps average from three-quarters of an inch to over an inch in length, and in green-tinted examples of the type, more especially, much resemble miniature fern fronds. The variations of colour to which this species is subject are numerous. In one of the commonest varieties, the disk and tentacles throughout are suffused with shades of olive-green, the central shafts of the tentacles being the darkest. In a second variety, the shafts of the tentacles are alone green, their pinnules and all portions of the disk being a pinkish-brown. In yet a third variety, the prevailing ground colours of the disk and tentacles are shades of light greenish-grey, some of the latter being also crimson-tipped. A crimson line, like a vein, runs up the central shaft of each tentacle; and the pinnules in this variety, while usually pale green, are in some examples nearly white.

Another attractive compound-tentacled anemone is represented by Figs. 2, 2A, 2B, and 2C of Chromo plate No. III. This type, when expanded, is somewhat elevated and conical in outline; but it alters its shape, when contracted, to an almost perfect spheroid. The tentacles are thickly developed throughout the area of the disk. The inner circlet, situated in the immediate neighbourhood of the mouth, contains some four or five tentacles only, which are simple in character; the remaining tentacles are compound and irregularly palmate or pinnatifid in outline, consisting of a short cylindrical central shaft, around the distal half of which, from five or six to as many as twenty secondary pinnules may be developed. When the tentacles are expanded, these pinnules are elongate and subcylindrical, while in the contracted condition they are drawn in closely to the central shaft, and are distinctly capitate or spheroidal, as shown in Fig. 2B of the plate referred to. In colour, this species was observed to exhibit two well-marked variations. In the one, the polyps were liver-brown throughout, excepting the tips of all the tentacle-pinnules, which were a brilliant golden-green. In the second variation the golden-green hue of the pinnule tips was replaced by a light pearl-grey. These two varieties of the same species were found growing massed together in patches of considerable size on the reefs adjacent to the Bay Rock lighthouse, Cleveland Bay, near Townsville. This species is provisionally referred to the genus Rhodactis. In the type form of that genus, *Rhodactis rhodostoma*, the tentacles nearly agree in structure and disposition, except that simple

tentacles are recorded as occurring on the outer margin of the disk and palmate ones around the oral orifice; in the present species, the few existing simple tentacles are stationed immediately around the mouth as shown in Fig. 2c. This anemone will probably have to be relegated to a distinct genus; in the meantime it is referred to its nearest known affinity under the title of *Rhodactis Howesii.* The name here proposed for its specific distinction is associated with that of Prof. G. B. Howes, of the Royal College of Science, to whom the author is beholden for much aid in the compilation of this work.

Included among the many varieties of simple-tentacled anemones indigenous to the Barrier reefs, the species illustrated by Figs. 9 and 10 of Chromo plate III. presents special features of interest. This type is remarkable for the length and thickness of the tentacles in proportion to the size of the polyp's body, their distal ends, moreover, under the condition of full extension, being greatly inflated. When only half-expanded, on the other hand, the tentacles most commonly assume a simply subulate contour. The life colours of this species are somewhat attractive. The relatively small depressed body is usually light or reddish brown; the shafts of the tentacles up to the dilated extremities are a clear dark brown, claret, or purple; and the swollen ends a delicate emerald-green, with a small white apical tip. The species is eminently social in its habits, occurring commonly in crowded masses in crevices and sheltered cavities among the coral-rocks, both at Thursday Island and in the neighbourhood of the Albany Pass. The broad external features of this anemone are so distinct from those of any form that has been described, that both a new generic and a new specific title have to be created for its reception. In accordance with the bladder-like apices of the tentacles, the generic name of Physobrachia (*physis*—bladder, *brachium*—arm) may be appropriately adopted for its generic cognomen; while for its specific distinction it is herewith associated, under the collective title of *Physobrachia Douglasi,* with the name of the Hon. John Douglas, the Government resident of Thursday Island, through whose liberal hospitality and ever ready assistance the author was greatly aided in investigating the marine fauna of Torres Strait.

Two relatively small species of Discosoma, near allies of the giant species described in a previous page, and illustrated by Figs. 12 and 13 of Chromo plate No. III., demand brief notice. The latter, identified by the author with the *Discosoma nummiforme* of Leuckart, rarely exceeds two inches in diameter; its relatively small dimensions, however, are compensated for by its rich colours. The disk, which is pentagonal in shape, and the supporting column, are most usually a rich purple-brown; and the almost sessile spheroidal tentacles, which nearly conceal the disk, are, for the most part, a brilliant emerald-green; some few in its inner confines, and here and there patches of its outer border, are of the same purple-brown hue as the body. This species was first obtained by the author at Adolphus Island, in Torres Strait, and subsequently at Rocky Island, off Cape Flattery. In the second species of Discosoma, which is nearly allied to *D.*

nummiforme, the disk is more symmetrically ovate or circular, and the tentacles, while similarly sessile and spheroidal, are mounted on projecting rugæ of the substance of the disk. Green is, in this instance also, the dominant hue, represented by duller shades of dark and yellow-green, which are disposed in alternate triangular bands, from the peripheral border towards the oral centre. The oral area, or stomodæum, projects centrally in the form of a cone, and is of a brilliant magenta hue. In respect to this last indicated feature, it is herewith proposed to associate it, in the absence of evidence of its previous discovery, with the provisional distinctive title of *Discosoma rubra-oris*.

The last type of the Actinarian order inviting attention in this chapter, *Cerianthus nobilis*, illustrated by Fig. 7 of Chromo plate III., is of special interest, on account of its close alliance with an indigenous British species; also with reference to the fact that it belongs to that more abnormal group in which the polyps either lie entirely unattached, and repose with their bodies simply concealed in the loose sand, or build up a sheath-like domicile through the exudation of mucus, and the entanglement therein of cast-out nematocysts, or extraneously derived substances. The present form belongs to the sheath-building category, and has been collected by the author at Warrior and Thursday Islands, in Torres Strait, and also at Port Darwin. The body of this anemone much resembles that of a large worm or bêche-de-mer; it is subcylindrical, about an inch thick, some seven or eight inches long, and of a deep chocolate-brown hue. The crown of tentacles that surmounts the smooth cylindrical body comprises two varieties. There is an outer wreath of attenuate, almost filamentous, tentacles that springs from the peripheral margin of the tentacular disk, and a second series of yet more slender tentacles, that grow out of the central throat cavity of the polyps, and are only visible in a direct end-on view. The colour of this inner fascicle of tentacles is usually pearl-grey; while those that form the outer series are most commonly a pale lemon-yellow, varying, among different individuals, to a dark red-brown or nearly black. It was observed of the specimens collected at Warrior Island that young anemones, with bodies an inch or so in length, were enclosed, in some numbers, in the substance of the felt-like sheath that is constructed by the parent polyps, whence, on arriving at a more mature age, they emerge to establish domiciles on their own account. The distinctive name of *Cerianthus nobilis* has been conferred on this type by Prof. A. C. Haddon, who, besides the author, has collected the species in Torres Strait.

ORDER II.—ZOANTHARIA.

Apart from the more familiarly known skeletonless, solitary, sea-anemones, there is a considerable group in which a greater or lesser number of individual anemone-like polyps remain attached to one another by a creeping rhizome or common fleshy base, after the manner of certain Alcyonaria hereafter described. These social anemones which, through continued

budding, unattended by separation from the parent polyp, form associated colony-stocks, have been relegated by biologists to the order of the Zoantharia.

The broad external feature that readily serves to distinguish the members of the social anemone order now under consideration, from their Alcyonarian allies, is the number of tentacles they respectively possess. These organs in the last-named group are invariably eight, while among the Zoantharia, as in the simple Actinaria, they are either a multiple of six or indefinitely innumerable. Again, whilst the tentacles of the Alcyonarian polyps are most commonly fringed or pinnate, those of all known Zoantharia are, without exception, perfectly simple. Among the types of the Zoantharian order that form a fitting parallel to certain Alcyonarian species, reference may be made to the very beautiful little variety, apparently identical with *Zoanthus Coppingeri*, illustrated by Fig. 11 of Plate III. of the chromo-lithographic series, which may be fitly described as one of the gems of this group. The combination and arrangement of the colours in this species are almost an exact counterpart of what obtains in the Alcyonarian form *Cornularia auricula*, represented by Fig. 8 of the same plate. Both specimens possess, in common, green oral centres surrounded by a fringe of rich brown tentacles. In the one instance, however, the tentacles are only eight, while in the other they are practically indefinite. The green oral centres in the Zoanthus figured were of exceptional brilliance; in other examples observed, this area was sometimes a lighter and duller green, and in other instances a darker bottle-green tint. The supporting base in this type, as also in the majority of the Zoantharia, is represented by a continuous fleshy expansion known as the "cœnosarc," in place of a subcylindrical creeping stolon such as obtains in Cornularia.

A second type of the Zoantharian series, *Palythoa cæsia*, is illustrated by Fig. 1 of Chromo plate No. III. The polyps in this form are not elevated on separate contractile stalks as in the foregoing species, but open out directly on mammiform elevations of the surface of the connecting "cœnosarc." The tentacles, moreover, are exceedingly short and rudimentary, forming a single incurved circlet round the inner margin of the hollow, crater-like, polyp-papillæ. As indicated in the accompanying illustration, the ordinary colour of the combined cœnosarc and polyp-elevations of this Zoantharian is a rich creamy-yellow, varying, however, to a lighter or darker shade in different colony-stocks, the circlet of minute tentacles in all instances being a more distinct brown. Patches of this composite polyp not unfrequently spread, as an incrustation, over reef-areas several yards in extent, and, in many instances, over the dead coralla of Meandrinæ, Goniastræas, or other Astræacææ. Under these last-named conditions, the Palythoa is somewhat liable to be mistaken for a solid Madreporarian.

A third and altogether unique modification of the Zoantharian structural type is exemplified by Chromo plate No. III., Figs. 4 and 4A. In this form, the associated polyps, in place of forming flattened adherent masses, build up an erect polypary that at first sight might be mistaken for a solid corallum. This polypary consists, however, of a tubular irregularly nodular central axis,

more or less completely encrusted by Zoanthoid polyps, that may attain to a height of fifteen or eighteen inches. Divested of the polyps by which it is constructed, this central axis is found to consist of a hollow core of thin, non-spiculiferous, papier-maché or leather-like material, averaging about half-an-inch in diameter, and having usually a more or less distinctly zigzag habit of growth. On examining a perfect polypary, the polyps are found to be clustered most thickly on the projecting outgrowths of the axial angles, the intervals between them being chiefly occupied by the fleshy substance. In the living state, moreover, these intermediate areas are commonly covered with minute algæ, zoophytes, and other marine growths that considerably mask its true nature. The adult polyps in this type expand to a diameter of about one inch; but they exhibit their most attractive colouring in their contracted, or semi-expanded state, it being only under such conditions that the brilliant emerald-green annular ring is visible, which lies sphincter-like around the tentacular wreath. The remainder of the body is usually a duller green inclining to pink, speckled with red-brown. The tentacles are usually a rich chocolate-brown, but sometimes somewhat purplish; the centre of the oral disk is a dull orange, spotted with red-brown, after the manner of the external body-surface The species now described is somewhat widely distributed, it having been collected by the author on the Barrier Reef from Torres Strait to opposite Mackay, and also at Port Darwin and Cambridge Gulf, on the North Australian coast-line. In all instances, the species was found growing, in a perpendicular position, on somewhat muddy foreshores, and it was exposed to view at about half-ebb-tide.

Dried Skeletal Tube of *Acrozoanthus Australiæ*, Nov. gen., n.sp., ⅔ nat. size: delineated from two separate points of view.

The endeavour made by the author during his residence in England to identify this Zoantharian with any previously known type has, while failing to elicit the information sought, given rise to interesting and debatable speculations concerning its actual affinities. A Zoantharian that secretes a tubular "sclerobase" has hitherto been unknown in the annals of zoophytology, and is consequently looked at somewhat askance by authorities

on this branch of biology. The suggestion offered in some quarters that it might not improbably be a worm-tube parasitically encrusted with a typical Zoanthus presented itself to the author's mind on first obtaining specimens at Port Darwin, in the year 1888. Several facts, however, militate against the acceptance of such an interpretation, which, if adopted, would involve the improvisation of a far more abnormally constituted worm than zoophyte. Although sought for diligently, no examples, either living or dead, or at any younger or more advanced stage of growth, could be discovered, in which the top or distal end of the tube was open, as obtains with the dwelling-tubes of all known tubicolous annelids, of which such genera as Sabella and Chætopterus may be cited as characteristic types. In all known worm-tubes, moreover, the lumen of the tube is smooth and cylindrical throughout, and does not deviate into zigzag angles or irregularly protruding nodes, of from two to three on the same horizontal plane, as obtains in the Zoanthus-associated structure. If, again, as suggested with reference to the simplest zigzag tubes, such zigzag line of growth had been induced by the Zoanthus repeatedly interfering with the worm and causing it to deviate from its normal rectilinear growth to alternate sides, worm-tubes of normal construction, either partly or wholly free from invasion by the supposed parasitic Zoanthus, should most assuredly have been found. One other detail of suggestive significance remains to be recorded. It is a distinctive feature of these Zoantharian associated tubes, that, as illustrated in the accompanying figure, their proximal or attached ends spread out to a greater width than the erect tube, after the manner of the attached base of a Gorgonia or other compound Actinozoarian. In the case of a fixed worm-tube, on the other hand, the tube is always smallest at its proximal or attached end, since it represents at that point the dwelling-house of the worm in its most juvenile tubicolous stage of development.

It may be remarked of the dried, somewhat eroded, example, photographically delineated in the accompanying figure, that while the base exhibits its characteristic expanded form, the tube, a few inches above, has, in drying (*cf.* the figure to the left) become compressed laterally in such manner as to appear conspicuously narrower at this point. The right-hand figure of the same specimen, taken from a different point of view, shows, however, that there is no actual narrowing of the lumen at the point named.

Taking all the foregoing data into consideration, it would seem illogical, pending further investigations, to adopt any other course than that of the provisional recognition of this organism as a modified representative of the Zoantharia, distinguishable from all previously-recorded types of that order by its habit of building up an erect tubular support, or, as it might be appropriately designated, a "zoothecium." A new generic title—none of the older ones befitting it—being required for its distinction, that of Acrozoanthus (*Akros*, high, tall, *Zoanthus*) is herewith provisionally proposed, the specific one of Australiæ, being

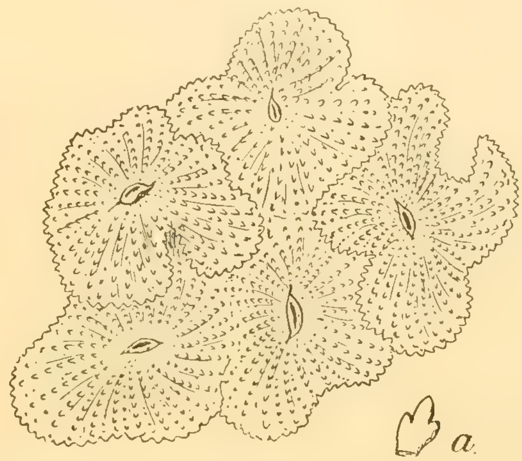
W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

MUSHROOM CORALS. FUNGIA CRASSITENTACULATA. EXPANDED. CONTRACTED. AND YOUNG ATTACHED CONDITIONS. NAT. SIZE.

added as indicative of its widely distributed, but, so far as is known, exclusive Australian habitat.

One other representative of the Zoantharia invites brief notice. This species is remarkable for the fact that it coincides in structure with what might be termed a skeletonless replica of the compound coral, hereafter referred to under the generic title of Mussa. The polyps in this type are flat, exceedingly irregular in outline, coalescing with one another in such a manner that two or three oral centres are frequently included in the same tentacular system. The tentacles are exceedingly short, in most instances minutely lobate, and developed over the greater portion of the area of the expanded disk. The life colours of the disk are a light greenish-brown, the tentacles redder brown and white-tipped, while the slightly-exposed inner lining of the oral opening is rose-pink. A single specimen only of this interesting type was obtained from beneath a reef-ledge at Vivien Point, Thursday Island. The individual polyps in this species, where enclosing only a single oral system, bear a considerable resemblance to those of Klunzinger's *Cryptodendrum adhaesivum*, but with the shorter-branched tentacles of *Rhodactis rhodostoma*, M. Ed., as figured in each instance by Andres. Drawings of the type, submitted by the author to Dr. Playfair McMurrich, the American zoophytologist, elicited the opinion that a compound form somewhat analogous to, although different from the Australian type, in details of generic import, had been recorded from the West Indian region by Duchassaing and Michelotti. It seems imperative here again to employ both a new generic and a new specific title for its distinction, and it is, accordingly, added to the list of Zoantharian species, in association with the title of *Platyzoanthus* mussoides*. Unfortunately, the space available for the illustration of the Zoantharia has been found insufficient for the inclusion of more than the diagrammatic outline of this interesting species given above.



PLATYZOANTHUS MUSSOIDES, Nov. gen., n.sp. Expanded colony-stock, ⅔ natural size. At *a*, a tentacle enlarged.

ORDER III.—MADREPORARIA.

The order of the Madreporaria, or Stony-corals (as they are popularly termed, with reference, to the more or less dense calcareous skeleton which they possess), necessarily repre-

* *Platus*, broad, *Zoanthus*.

sents the most important group associated with the phenomenon of reef-construction. It will not be attempted in these pages to describe each and every species that has been observed or collected by the author in the Barrier region categorically. To accomplish such a purpose, doing full justice to the subject, would require a volume in itself, of a size larger than the present one. Attention will be here directed only to those most conspicuously attractive or constructively important species, that are either prominently represented in the accompanying photographic reef-views, or are typically illustrated in their natural colours in the succeeding chromo-lithographic plates.

The production of a simple but complete list of all the varieties collected in this productive district is, as a matter of fact, also an impossibility. The examination, comparison, and determination of the actual affinities, and in many instances the diagnostic definition, of new, or hitherto imperfectly-described, species, is in itself a task demanding years for its accomplishment. Fortunately, on arriving in England with his collection, the author found that Mr. George Brook, F.L.S., well known for his admirable report on the *Challenger* Antipatharia, or black corals, had been entrusted with the compilation of the long-promised Catalogue of the British Museum Madreporaria, and had been occupied throughout the previous year with the study and nomenclature of the single genus Madrepora. The author's collection, which he presented to the Trustees of that Institution for incorporation with the National series, consequently arrived, as the saying runs, just in the nick of time. Hitherto, the number of species of reef corals definitely associated with an Australian habitat has not, according to the *Challenger* reports (*Reef Corals*, Vol. XVI. p. 22), exceeded sixty-one. The genus Madrepora exemplified by the author's Barrier district collection, which has alone, so far, been investigated by Mr. Brook, numbers over seventy species, including a large increment of new ones. The remaining varieties, of which it is impossible at present to give an exhaustive catalogue, are likely, at all events, to bring the number of authenticated Australian reef corals to at least two hundred. A general estimate of the various generic groups, together with a rough approximate calculation of the variety of species they severally contain, is nevertheless embodied in the appendix to this volume. In so far as the genus Madrepora is concerned, the catalogue, worked out and furnished to the author by Mr. Brook is a complete one.

A nearer examination may now be made of the specific varieties of corals that enter most conspicuously into the composition of the Great Barrier reefs. On the system of classification adopted in the list forming the appendix, the first natural group or family to attract attention is that of the Euphylliaceæ. The members of this group are distinguished by the possession of a coral-skeleton or corallum, that takes the form of hemispherical clusters of individual coral cups or corallites, formed by repeated bifurcation, which are either entirely independent of one another at their extremities, or occasionally united in

simple linear series. The numerous thin, calcareous, radiating laminæ or "septa" that form the inner lining to each separate cup are, as compared with certain otherwise somewhat approximate species, perfectly smooth-edged. The tentacles of the living polyps in this group are, in their most fully-expanded state, also remarkable for their spherically knobbed or otherwise conspicuously inflated terminations. This coral family, so far as it is represented in the Great Barrier system, is exclusively confined to the warmest equatorial region, having been obtained by the author most abundantly in Torres Strait and thence southward as far as the Cairn Cross islands. Among the reefs opposite Cooktown, between latitudes of 15° and 16° S., and in all localities investigated farther south, the Euphylliaceæ are apparently entirely unrepresented.

In the Torres Strait district as many as three genera of the Euphylliaceous family have been collected by the author. The most abundantly represented one among these three is the typical genus Euphyllia, in which the matured coralla form hemispherical clusters, and the component digitiform corallites, increasing by dichotomous subdivision, are more or less independent at their distal or growing terminations. The dimensions of the hemispherical coral-masses of this genus are not large; their measurement, from the centre to the periphery, rarely exceeds eight or ten inches, and they are in most instances much smaller. The expanded polyps in this genus are among the most beautiful in the coral class, being surmounted by tufts of cylindrical tentacles the extremities of which, in full extension, are knobbed like the head of a snail's horn or drumstick, and of various colours. In the larger of the two species observed, *Euphyllia glabrescens*, the tentacles vary more commonly from a rich seal-brown to a dark myrtle-green, the rounded tips being white, blue-grey, or golden-yellow. In rarer instances the tentacles are a brilliant grass-green, with pale lemon-yellow tips. In the second and smaller species, *Euphyllia rugosa*, the tentacles are usually slate-grey or lilac, with brilliant emerald-green terminal knobs. An interesting observation was made by the author, with reference to the variation in colour that may obtain among the polyps belonging to the same colony-stock, or corallum, of *Euphyllia glabrescens*, in relation to the amount of light to which they are exposed. An example observed in the neighbourhood of Thursday Island was so growing, that certain of the polyps projected underneath and were shut out from the light by surrounding coral growths. In this completely shaded position the tentacles were transparently white with pale primrose-coloured tips. Where the light only partially fell on them, the tentacles were sage-green with brighter yellow tips; while, throughout the area fully exposed to the sunlight, all the tentacles were dark brown, with deep golden terminations. Corresponding illustrations of the effect on the colours of coral-animals, produced through the absence of light, were subsequently observed among the representatives of the two genera Mussa and Galaxea, hereafter referred to. In all the genera named, the polyps screened from light were similarly bleached, after the manner of cultivated sea-kale or celery. Characteristic coloured illustrations of the polyps of the genus Euphyllia, in various conditions of

expansion, will be found in the Chromo-lithographic plate No. IV., and a separate photographic figure of *Euphyllia rugosa* in the Phototype plate No. XXV.

A very attractive representative of the family Euphyllidæ is delineated by Fig. 7 of Chromo plate IV. In this coral the polyps multiply in a similar manner to that of Euphyllia, by subdivision or fission. In place, however, of separating entirely and producing independent corallites, as is the case with the last-named genus, they remain united laterally, and so form undulating linear series of greater or lesser extent. It is a further distinction of the members of this genus that the coralla, while attached in their youngest condition to other coral-growths by a slender stalk, become separated, and lie free on the reef at an early stage of their existence. The colours of the living polyps in this handsome coral are more brilliant even than those of the Euphylliæ. As seen in their fully-expanded state, the centres of the polyps are emerald-green variegated with brownish striæ, while the tentacles are primrose or lemon-yellow, with the most brilliant lilac or magenta tips. When fully extended, these tentacles are over an inch long, and the lilac tips are spherically inflated, as represented in the figure. When only partly extended, as obtains in the photographic illustration from life reproduced in Plate XXV., Fig. 2, the tentacles are simply subulate, and do not exceed half-an-inch in length. This same variation in the shape of the apical terminations of the tentacles, in accordance with their greater or lesser degree of extension, has been occasionally observed also, it should have been mentioned, in *Euphyllia glabrescens*.

Some difficulty has been experienced in the relegation of this coral to its correct systematic position. Whilst, in its general aspect, the corallum most nearly resembles that of Pterogyra or Rhipidogyra, its early pedunculate, and later unattached conditions, suggest a nearer affinity with Pectinia. To the latter genus, under the provisional title of *Pectinia Jardinei*, it is herewith provisionally referred. Examples of the species were collected on the Barrier Reef at Thursday Island, and also, more abundantly, in the Albany Pass, near Mr. Frank Jardine's settlement at Somerset. The specific title has been conferred in recognition of the substantial assistance the author received from Mr. Jardine, when investigating the coral and marine fauna of the Torres Strait district.

A considerably rarer representative of the family group now under consideration, obtained by the author from North Queensland, is apparently identical with *Rhipidogyra laxa*. The corallum in this type closely resembles that of Pectinia, last described, its corallites being similarly united in meandering series. A single specimen only of this handsome coral was collected, the locality being, in this instance also, the fringing reef in the Albany Pass. The tips of the tentacles in the living polyps were a brilliant emerald-green, and remarkable for their inflation in the form of a kidney or irregularly-shaped crescent. The stalks or shafts of the tentacles, and also the united central polyp-disks, were, by way of contrast, a rich red-brown. A fragment of the living corallum, with its polyps expanded, is represented by Fig. 1 of

Chromo plate No. IV. The diameter of the coral-stock in its unbroken state was about eighteen inches.

A generic coral genus that is usually allotted a systematic position in the vicinity of Euphyllia, is that of Galaxea. The compound coralla of the species of this genus take the form of lobate or encrusting masses of considerable size, which may include many hundred individual corallites. The corallum, divested of its organic tissues, presents a remarkable appearance, that readily distinguishes it from any other coral type. Its component corallites are subcylindrical, rarely thicker than an ordinary lead-pencil, and, projecting for half-an-inch or so in close proximity to one another, they form a basal calcareous substratum, looking like bleached almonds thickly inserted in a frosted cake. The apparent independence of the individual corallites, as thus viewed, is entirely superficial. On cutting away the intervening basal calcareous matter, technically termed the "cœnenchyma," these corallites can be traced downwards until they are found to be united with their fellows. The crowded mass has, in fact, been developed by a process of continued fission and gemmation, from a single original corallite; and the entire structure may therefore be aptly compared to the corallum of an Euphyllia, in which a secondary deposit of calcareous cœnenchyma has filled up the interspaces between the component corallites, to such an extent that their distal terminations are alone visible.

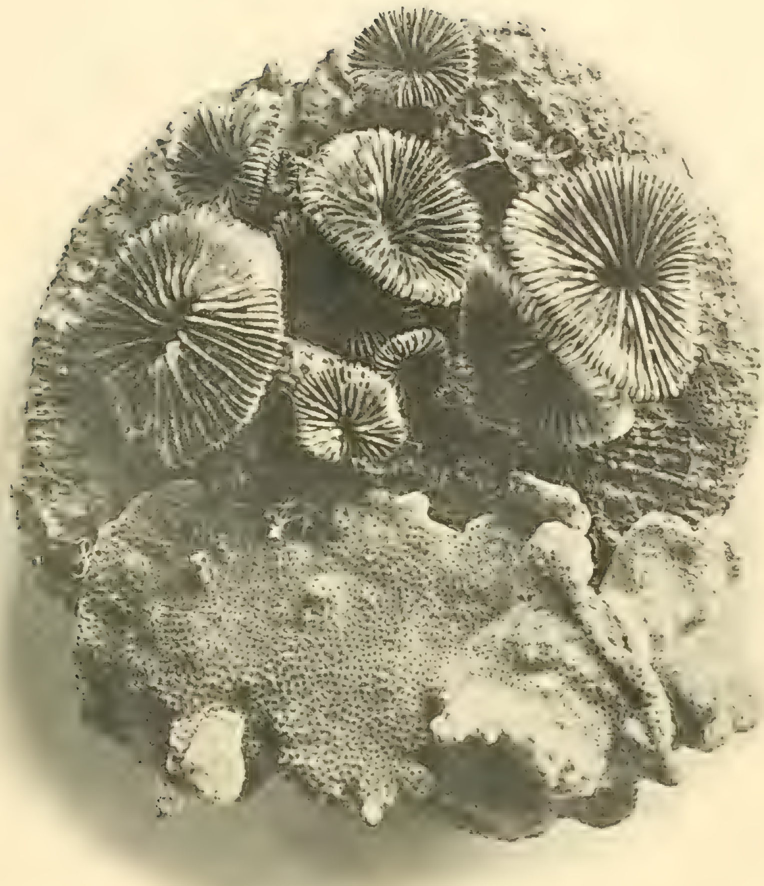
The living polyps of the genus *Galaxea* correspond, to some extent, with those of Euphyllia. The tops of the tentacles in their normally extended state are distinctly knobbed, while greens and browns of various shades represent the dominating tints. The tentacles, however, are much fewer, being usually twenty-four in number; as in all corals, their number corresponds with that of the internal subdivisions or septa of the coral cup. The six largest of these septa, forming what is termed the primary cycle, project to a considerable extent beyond the rim of the corallite, and their corresponding tentacles in the living organism stand up vertically above their fellows of the second cycle, which, for the most part, assume a horizontal direction. In many instances these six erect, primary, tentacles differ conspicuously in hue from the more abundant horizontal series. In one corallum of *Galaxea Esperi*, collected on the Warrior reef, the six erect tentacles were purplish-brown with white terminal knobs, and the horizontal ones a bright grass-green with paler knobs of the same tint, as delineated in Fig. 9 of Chromo plate No. IV. In another instance, the erect tentacles were green and the horizontal ones light brown; while in other colony-stocks the polyps were uniformly tinted, and ranged in colour from lemon-yellow to bright grass-green. In the Galaxea, briefly referred to in the preceding description of the species of Euphyllia, as exhibiting, through partial isolation from sunlight, an abnormally bleached condition, the polyps on the upper or exposed surface were a pale brown with lighter tips, the six erect tentacles having a yellower tinge. On the under, light-screened, surface, of the same corallum, the more numerous horizontal tentacles were transparent white,

and the six erect ones pale primrose. Figures illustrating additional species of Galaxea are included in Chromo No. 4, already named; while the general aspect of the corallum as growing *in situ* may be gained by reference to the photographic reef-view, Plate X2, wherein an extensive colony-stock of *Galaxea Esperi* occupies a prominent position in the left-hand foreground. The reef illustrated is adjacent to Stone Island, Port Denison, from which point to the northernmost limits of the Great Barrier region various members of the genus occur in abundance. An entire bleached corallum of the above-named most cosmopolitan type of this genus is represented in Fig. 13 of the first of the series of photo-mezzotype illustrations.

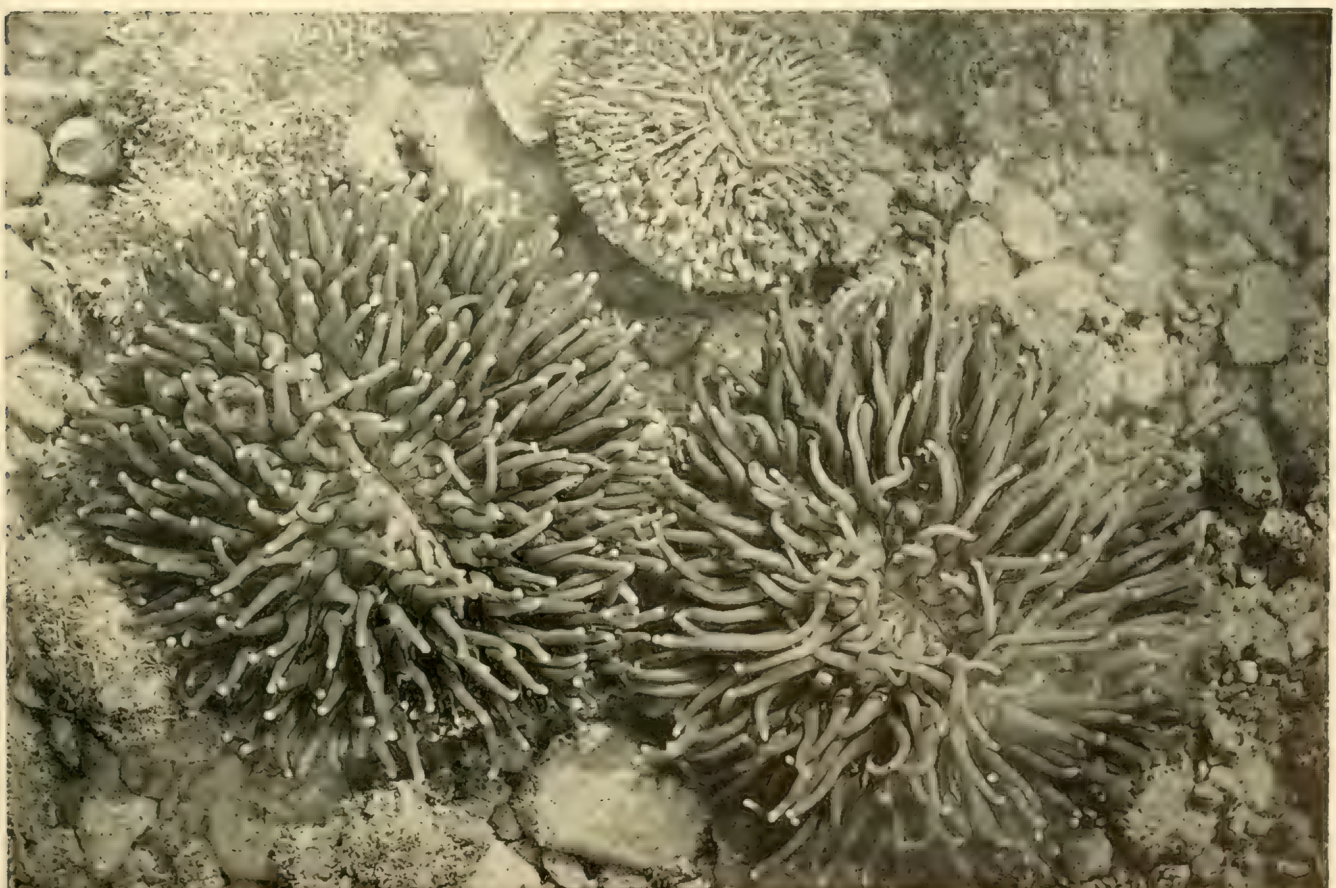
The next coral group that invites attention is that of Mussa and certain allied genera. In its simplest form, Caulastræa, the corallum much resembles that of Euphyllia, it being composed of slender subcylindrical corallites, which increase in a similar manner by repeated bifurcation. It is placed in a separate group, however, from Euphyllia, and the other types already enumerated, in accordance with the characters of the internal radiating plates or septa, which, instead of being perfectly smooth, or entire, are distinctly notched, or serrated. The character of the tentacles in the living polyps of Caulastræa and its allies is also distinct from that of the Euphylliæ, being simply pointed or subulate, instead of distinctly knobbed or capitate. A figure of *Caulastræa distorta*, which has been obtained by the author at various localities, from the Warrior reef in the north to the Palm Islands in the south, with the polyps expanded, is given in Fig. 2 of Chromo plate No. V. The coloration of the living polyps, while not so brilliant as that of the Euphylliæ, is attractive. The external surface of the corallites varies from reddish to a bright golden-brown; the central or oral disk is a more or less brilliant green, and the surrounding fringe of subulate tentacles is perfectly transparent.

An advance of complexity in structure is presented by the genus Mussa. In the members of this group the entire outer and inner surfaces of the component corallites bristle with spines and serrations to such an extent, that they require careful handling. The names *Mussa cactus, carduus, dipsacea, horrida,* and *spinosissima*, which have been conferred on various members of the genus, are of themselves amply indicative of their prickly character. The individual corallites in this genus never present the even, subcylindrical, contour, characteristic of Euphyllia or Caulastræa; but their distal polyp-bearing ends broaden out into shallow cups two or three inches in diameter and of the most irregular shape, such shape being, to a great extent, determined by that of the abutting walls of the neighbouring corallites. These corallites, moreover, are rarely single, as in the types previously enumerated; two or more oral centres, representing conjoint polyps, being most frequently included within the same corallite. This initial phase of complexity paves the way to the still more intricate structural plan that obtains in the genus Symphyllia.

The colours of the polyps in the genus Mussa somewhat resemble those of Caulastræa. Brilliant green centres, with red-brown corallite rims and transparent tentacles, most frequently



No. 1. MUSHROOM CORAL WITH ATTACHED YOUNG. NAT. SIZE



W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

No. 2. MUSHROOM CORALS, FULLY EXPANDED, $^2/_3$ NAT. SIZE.

occur. In other instances the entire living tissues are a deep rich brown, or brown and green variously blended; while in one luxuriant species, *Mussa corymbosa*,—whose separate corallites may be eighteen inches long, and the entire corallum two or three feet in diameter,—all of the component tissues are bright brick-red, and the extended tentacles a transparent tint of the same colour. In the structure of their tentacles, the polyps of the genus Mussa differ in a marked manner from those of Caulastræa, and other species previously enumerated. Their essential feature, in the expanded state, is typically illustrated by Fig. 3A of Chromo plate V., representing a diagrammatic vertical section of an expanded polyp of *Mussa corymbosa*. As here shown, short, acuminate tentacles are developed in a fringe-like manner throughout the surface of the oral disk, or peristome, while the extreme edge of this tentaciliferous area projects laterally—terminating in section, in a fine point—to a considerable distance beyond the edge of the corallite. The short acuminate tentacles thus exhibited in a linear series would seem to correspond with the coarse serrations of the subjacent septa. The polyps of the green and brown *Mussa multilobata* are shown, under corresponding conditions of contraction and expansion, in Figs. 4 and 4A of the same plate. In this species, however, the peristomial disk and associated tentacles, when fully inflated by injected water, are, in the lightest coloured examples, very nearly transparent. The genus Mussa is one of the most cosmopolitan types, being represented in more or less abundance throughout the Barrier district. Several masses of the commoner brown species, *Mussa multilobata*, occupy a central position in the photographic view, Plate X., No. 1, representing the fringing reef in the neighbourhood of the Palm Islands. A bleached corallum of the same type is likewise included in Plate I. of the same series.

A very distinct generic type, nearly allied to Mussa, but differing from it in the facts that the mature corallum is detached and lies freely on the sea-bottom or surface of the reef, and that the septal edges and external ridges, or costæ, are very finely serrated instead of coarsely toothed, is that of *Trachyphyllia amarantus*, represented in Figs. 1, 1A, and B of Chromo plate No. V. In its adult, detached, and pedicellated young condition of growth, the corallum of this genus corresponds with that of Pectinia; but it does not attain to such large dimensions, rarely exceeding five or six inches in diameter. The tentacles of the living polyps of Trachyphyllia differ from those of Pectinia in being attenuate and transparent, like those of Mussa, but are slightly inflated at their tips; they are also similarly developed in a fringe-like manner throughout the peristomial region. The membrane of the oral disk, and that covering the surrounding septal edges in this species of Trachyphyllia, are liable to considerable colour variation. In some specimens they are dark brick-red throughout, and in others elaborately variegated with shades of green, brown, red, and yellow in diverse combinations; but all these colours may co-exist in the same corallum. The typical Barrier species, *Trachyphyllia amarantus*, has been obtained by the author on exposed reefs near Warrior and Thursday Islands, and also, by dredging, in Cleveland Bay, off Townsville, at a depth of three or four fathoms, but not farther south.

A genus of corals that possesses structural features very closely resembling those of Mussa, and whose colony-stocks play an important *rôle* in the constitution of the great Barrier reefs, is that of Symphyllia. In this genus, the full-grown coralla are represented by large solid, dome-shaped, masses, that may measure many feet in diameter, which, from their sinuous surface patterns, considerably resemble the typical Brain-stone corals or Meandrinæ. On near examination, the meandering ridges and valleys of Symphyllia are found to exhibit a structure which may be aptly compared with colony-stocks of Mussa, having their corallites so closely compressed, that their boundary walls, or "thecæ," have become completely soldered together, while the corallites, instead of being sufficiently elongated to enclose only two or three oral openings, are continuous with one another in simple or branched sinuous series of indefinite extent.

The expanded living polyps of Symphyllia, excepting for their extended serial union, resemble those of Mussa in all essential respects; the tentacles being subulate, transparent, and projecting in the form of a fringe along each peristomial border. It has been further observed by the author that the polyps of this genus, in common with those of Mussa, rarely expand in the daylight, and must be examined by night to be witnessed in a condition of full extension. This fact was established, by preserving examples alive for a considerable time in an improvised aquarium on board H.M.S. *Rambler*. During the daytime, the polyps remained persistently closed, but they expanded in full filmy splendour as soon as night set in. The same phenomenon was found to obtain among a large number of the ordinary Star-corals, Astræaceæ, hereafter noticed, and would appear to account for the fact that, while the living membranes of the oral disks and intervening areas, which are exposed to the light when the tentacles are retracted, are always distinctly, and also brilliantly, coloured, the tentacles themselves, which only expand in the dark, are transparent or colourless. Examples of reef photographs in which the coralla of the genus Symphyllia constitute a conspicuous feature are furnished by Plates II., III., VI., VII. of the photo-mezzotype series. As is the case with the genus Mussa, the dominating hues of the investing membranes of the living coralla are of various shades of green and brown. The commoner species, *Symphyllia hemispherica*, which forms the large domes previously referred to, is usually a dark liver-brown throughout, while in the rarer *S. sinuosa*, or its near ally, represented by Chromo plate No. V., Fig. 17, the valleys, or polyp centres, are a rich velvety green, and the intervening septal ridges golden-brown. As with Mussa, the members of the genus Symphyllia are distributed throughout the length and breadth of the Barrier district.

The extensive group of the Star-corals, or Astræaceæ, demand attention next. The members of this tribe are, however, so numerous, that a few only of the more conspicuous Barrier species can be here enumerated. The feature common to all the typical representatives of this coral group is the solid, imperforate structure of the calcareous corallum, which consists of innumerable corallites, most frequently of polygonal outline, closely united to one another

throughout their peripheral edges. The genus Goniastræa, which represents one of the most numerically abundant constituents of the high-level and shoreward edges of the Barrier reefs, furnishes an appropriate illustration of this series. *Goniastræa Grayi*, the commonest Australian species, is conspicuously *en evidence* in a considerable number of the reef-views reproduced in this volume, and will be found to exhibit a considerable diversity of contour. A near view of a typical colony-stock of this coral will be found in the foreground of Plates II. and III. of the phototype series, occupying the left-hand side in the first, and the right-hand one in the second plate, and representing, as a matter of fact, opposite aspects of the same corallum. Being so much in the foreground, every individual polygonal corallite, or polyp centre, of the compound structure is here distinctly visible. Another example in which, in the middle and farther distance, the same species is so abundant that its rounded coralla present somewhat the appearance of a flock of sheep is furnished by Plate V., No. 2. Examples in which the coralla form almost perfect spheroids are illustrated by Plates VI. and X., while in Plate XIV. a very singular departure from the normal growth occurs. In this instance, somewhat towards the left in the middle distance, a corallum of a type allied to *Goniastræa eximia* has been so indented, or interrupted, in the course of its natural growth that it presents the most grotesque resemblance to a human head. A descriptive account of this remarkable reef is given on page 24.

The living colours of *Goniastræa Grayi*, referred to in the foregoing paragraph, and illustrated by Fig. 21 of the Chromo-lithographic Plate No. V., are either a dark liver- or a golden-brown, no brighter tints having been in any instance found associated with it. In the second species, named *Goniastræa eximia*, which frequently grows close beside *G. Grayi*, the immediate centres of the polygonal corallites are often pale green, and the surrounding septal edges light brown, or in rarer instances pale pink or lilac. The coralla of this species are much more irregular in shape than those of *Goniastræa Grayi*, being usually divided up into smaller lobate segments. A typical illustration of a reef on which this species represents the dominant type is furnished by Plate IV., No. 1, wherein is delineated the foreshore area of one of the most characteristic fringing-reefs of the Palm Islands.

Among the many species of Barrier Star-corals, or Astræaceæ, that agree very nearly in structure with the Goniastrææ, there are some few which are noteworthy, on account of their brilliant coloration. The genus Prionastræa is especially conspicuous in this association. In one species in particular, *P. robusta*, the coralla, in the living state, vary in hue from the most brilliant emerald-green to straw-colour, with equally brilliant green oral centres; or, again, they may be straw-colour or light buff throughout. In place of forming sub-globose or evenly-rounded colony-stocks, this generic type produces coralla which are usually partly encrusting and partly raised in the form of irregular angular outgrowths. Delineations of the characteristic aspect of two diversely-tinted living coralla of *Prionastræa robusta* are included in Figs. 15 and 16 of

Plate V. of the chromo-lithographic series. The polyps, as is the case in the genus Goniastræa, possess innumerable subulate colourless tentacles that correspond in number with its septal divisions, and expand chiefly at night. Figures 5 and 8 of the plate above referred to depict other brilliantly-coloured members of the genus Prionastræa whose specific identity has not yet been satisfactorily determined. In the one instance, the polyp centres are grass-green and the septal ridges dark brown; in the other, lilac-brown polyp centres are associated with bright sage-green septal ridges.

In the same manner that the corallum of the genus Symphyllia, with its coarsely spinous undulating valleys and ridges, has been shown to be structurally related to that of Mussa, the true Brain-stone corals represented by the genus Cœloria, Leptoria, Meandrina, and a few other allied forms may be demonstrated to be structural modifications only of the genera Goniastræa, Prionastræa and their allies. In *Goniastræa Grayi* it may, in fact, be frequently observed that three or four of the corallites, or polyp centres, in place of being separated by their septal ridges, have remained united in a linear series. The repetition of this phenomenon on so extended a scale as to embrace as many as a dozen or more of the constituent corallites, united in branched or sinuous lines of variable length, would produce a structural pattern, similar to that which obtains in the genus Cœloria. Like Goniastræa, Cœloria enters very extensively into the composition of the Great Barrier reefs, and may be recognised as occupying conspicuous positions in many of the photographic views reproduced in this volume. Among these, Plates III., VII., and VIII. of the photo-mezzotype series may be specially cited, as including in their foregrounds large hemispherical masses of the commoner species, which is apparently identical with *Cœloria sinensis*. Like the Goniastrææ, the Brain-stone corals enjoy a cosmopolitan distribution throughout the Barrier district, and are among the earliest to be uncovered by the receding tide. Although the common specific form last named, like *Goniastræa Grayi*, is usually either a sombre or a golden-brown hue, there are several allied types that exhibit a marked diversity of colour. In one species, allied to *Cœloria Esperi* and *C. arabica*, the valleys, or polyp-furrows, are dark violet, and the intervening septal ridges golden-brown. In another variety of the same species, the septal ridges are amber-coloured and the polyp-furrows pale green; while in a third species of apparently the same type, the septal ridges are dark brown, and the polyp centres either pale aquamarine or sage-green. In yet a fourth variety of the same, or of a very closely-allied species, the corallum is a light sage-green throughout. In a fifth local variety, obtained only from the Palm Islands reefs, the narrow septal ridges are light brown, and the wider intervening polyp-furrows a dark bottle-green. The colours here enumerated are characteristic of the coralla in their living condition, with the polyp-tentacles retracted, as obtains when the tide recedes from the reefs, or even when the coralla are covered by water in full daylight. The expanded tentacles in all the species observed were either entirely colourless, or reproduced the palest shade of the same tint as the adjacent polyp centres Figures, illustrative of the retracted living aspect of some of the most characteristic of the

species of Brain-stone corals just enumerated, will be found in Plate V. of the chromo-lithographic series.

A point of interest is attached to the small rectangular area numbered 18A, in the left-hand bottom corner of the plate just named. It represents a basal area of the corallum of the Cœloria delineated in Fig. 18, in which two new polyp centres are making their appearance in the connecting substance or "cœnosarc." In the centre, farthest to the left, the polyp is single and circular, like that associated with the single corallite of the species of Favia, indicated by Fig. 14, a little higher up. In the polyp centre to the right, fission of the primary polyp has already proceeded to such an extent, that two independent oral apertures occupy the clearly defined peristomial area. It is by repeated incomplete fission of a corresponding nature that the elongated, more or less devious, polyp-valleys of this and the many allied "Brain-stone" corals are gradually built up.

There is one other specimen included in Chromo plate V. that invites brief notice. This is represented by Fig. 9, a single large green, polygonal, central corallite and two small lateral cups which have been produced from the larger corallite by the process of lateral gemmation. The species is identical with the *Moselya latistellata* of Quelch, one of the most interesting of the Madreporaria collected by the *Challenger* expedition. The importance attached to this coral is associated with the fact that it is, structurally, more nearly allied than any known living type to the ancient paleozoic genus Cyathophyllum, and finds its natural position within the same family group of the Cyathophyllidæ. The most essential diagnostic features of the Cyathophyllidæ, which includes a larger paleozoic sectional group of the Rugosa, are that the septal elements are represented by multiples of four, instead of by six, as obtains in all other known existing Madreporaria, as also the constant presence of horizontal partitions known as "tabulæ," which give to the corallite, in section, a distinctly camerated plan of structure. The single specimen obtained by the *Challenger* was dredged off Wednesday Island, in Torres Strait, at a depth of eight fathoms. Examples of the same species were collected by the author, at both Thursday Island and in the Albany Pass, Torres Strait, growing on the reefs at extreme low water mark. As indicated in the accompanying illustration, Chromo V., Fig. 9, the colour of the living corallite is, with the exception of the oral area, an intense emerald-green. A species closely allied to this form has been collected by the author, in the neighbourhood of Port Darwin. The occurrence of this paleozoically-allied coral on the Australian coast, in conjunction with this region, representing the only one that now produces living Trigoniæ, forms an interesting pendant to the geologically ancient affinities of the Australian terrestrial and aquatic fauna, as exemplified by the Marsupial and Monotreme mammals and Osteoglossum and Ceratodus among the fresh-water fish.

The sub-section of the Star-corals, represented by what are technically known as the typical Astræaceæ, remains to be mentioned. The members of this group differ from *Goniastræa* and

its allies, previously described, in that the corallites or polyp centres, in place of being crowded together so thickly that their divisional or septal walls are closely united, are more or less widely separated; the intervening spaces being filled in, after the manner of Galaxea previously described, with a separate calcareous deposit, technically termed the "cœnencyma." As a result of the absence of the lateral pressure that induces the polygonal contour of the corallites of Goniastræa and its allies, those of the group now under consideration are all, more or less, symmetrically circular. In certain of the genera of this group, such as Plesiastræa, Cyphastræa, and Heliastræa, whose habit it is to expand in the full sunlight, the colours of both the polyps and the intervening investing membrane, or "cœnosarc," are conspicuously brilliant. Thus, in the form apparently identical with *Plesiastræa versipora*, illustrated by Plate VI., Fig. 2, of the coloured series, the common investing membrane is a bright peacock-green, and the oral centres of the polyps are white, and the tentacles dark brown. In a second species, allied to *P. Peronii*, Figs. 1 and 5 of the same plate, the ground colour is lilac, and the polyps light grey-green with bright lilac-tipped tentacles; or, again, the polyps may be a delicate lilac, and the tentacles white tipped. In all the species just enumerated the polyp-cells or corallites are small, not exceeding a quarter of an inch in diameter. The polyps are at the same time capable of extension to the distance of an inch or more beyond their cell-orifices; and in this respect, together with their possession of twenty-four subulate tentacles, they closely resemble those of the perforate coral section hereafter referred to, under the genera Alveopora and Rhodoræa.

The coralla constructed by the types last named are, as compared with those of the Goniastrææ and Meandrinæ, rarely of large dimensions, and they may assume either an encrusting hemispherical or an irregularly lobate contour. The area of distribution of Heliastræa and its allies is co-extensive with that of the Barrier district. The dead coralla of a species of Cyphastræa have been collected by the author as far south as the shores of Moreton Bay.

A genus belonging to the same tribe of the Astræaceæ, viz., Favia, is still living in the last-named locality, and represents one of the few survivors of a number of species that until within a comparatively recent date flourished in this southern, extra-tropical, region. Both the coralla and the individual corallites of the genus Favia attain to a large size, the former being often represented by hemispheres, or sub-spherical agglomerations, two feet or more in diameter, while the corallites may be from half to three-quarters of an inch in width. Like those of Cyphastræa and Heliastræa, the corallites of Favia, in their typical condition, are sub-circular, and separated from one another by a greater or lesser amount of intervening calcareous matter, or cœnenchyma. It was observed of the species common to Moreton Bay, which very nearly resembles the *Favia Ehrenbergi* of Klunzinger, that a very considerable amount of structural variation may occur in a single corallum. Specimens were obtained, in point of fact, in which, while in one portion of the corallum the corallites exhibited their normal distinctly separate circular contour, in other parts they were crowded together without any intervening spaces, and

were by such crowding compelled to assume a polygonal shape. Finally, in these abnormally crowded areas the septal divisions between the adjacent corallites were wanting, and they were united together in a linear series, after the manner of a Cœloria or Meandrina. The colour that would appear to be almost universally represented in the living coralla of the genus Favia is that of a light-straw or lemon-yellow, sometimes variegated with a lesser amount of green or brown The tentacles of the extended polyps, like those of Goniastræa and its allies, are completely colourless, and expand chiefly at night. The natural tints of the living corallum of a species of Favia apparently identical with *F. amicorum* is represented by Fig. 14 of the Coloured Plate No. V. In No. 6. of the same plate a second variety, very closely allied to *Favia Bowerbanki*, is similarly depicted.

Leaving for a while that typical section of the Astræaceæ which is characterised by the production of more or less massive coralla, some attention may be directed to a few members of the group that exhibit a somewhat abnormal structural plan. Certain of these, known as the Lettuce-corals, Tridacophylliæ, are characterised by the construction of coralla which take the form of coalescing foliaceous expansions of paper-like tenuity and exceeding brittleness, and that in certain species present a by no means remote likeness to leaves of the lettuce and endive tribe. This resemblance is more especially sustained among such species as *Tridacophyllia laciniata*, illustrated by Fig. 12 of Chromo plate V., in which the predominating hue of the corallum is a brilliant green. In other examples of the same species, as depicted in Fig. 13 of the same plate, a bright golden-yellow represents the prevailing tint. In both varieties the edges of the paper-like folia were white or yellow, or a very pale tint of the characteristic ground hue. The polyp centres in this genus are almost exclusively confined to the oasis of the deep cups or valleys formed by the surrounding elevated folia, and are stationed either singly or in sparsely-scattered serial order. Living specimens of these Lettuce-corals, preserved for some days in improvised aquaria, failed to reveal the possession by the polyps of tentacles other than of a very minute and rudimentary description, which were developed only on the edges of the septal ridges in the near neighbourhood of the mouth. The region of the mouth, it should be mentioned, in the condition of fullest expansion observed, is elevated, as indicated in the figure-named, in the form of a distinct cone, or hypostome. In accordance with the writer's investigations, the members of the genus Tridacophyllia are essentially characteristic of the Mid-Barrier district, being especially abundant in the neighbourhood of the Palm Islands and Port Denison. Fully-developed coralla of the species here illustrated not unfrequently form foliaceous clumps, a foot or more in diameter; but, as usually found growing on the tidally-exposed reefs, they more commonly attained to only half that size.

In addition to the species, apparently identical with *Tridacophyllia laciniata*, above described, a very distinct form of the same genus occurs in some abundance on the Palm Islands reefs. In this type, the edges of the septa pertaining to the two primary cycles exhibit a strong tendency

to become thickened throughout their length, and more especially at their distal ends, where they are usually excurrent, with their surfaces finely echinulate. There is also a marked proclivity of the primary and a few of the adjacent septa in this type to become elevated as simple or forked branchlets, above the general level of the corallum. In the two characteristics enumerated, the Tridacophyllia combines, in a noteworthy manner, the diagnostic features that distinguish two separate species of the same genus, recognised as new by the author some years since, when engaged in the arrangement and nomenclature of the Madreporaria in the British Museum collection, which were described and figured by him in the *Proceedings of the Zoological Society* for the year 1871, under the titles of *Tridacophyllia alcicornis* and *T. echinata*. In anticipation of the Palm Islands type proving to be a new species, it is herewith associated with the provisional title of *Tridacophyllia Queenslandiæ*.

Another exceptional Astræacean genus, which has been obtained somewhat sparingly by the author from both the northern and central Barrier districts, is that of Merulina. The typical Barrier Reef representative of this genus, *Merulina ampliata*, likewise forms elegant foliaceous coralla, which may be of considerable extent, and are frequently developed in the form of elevated crests and frills. Unlike Tridacophyllia, the polyp centres in this generic type are relatively small, and are thickly distributed throughout the surface of the corallum in sinuous or branching series, somewhat after the manner of those of a Meandrina or Cœloria, but on a much more irregular and interrupted plan. As in Meandrina, the polyp tentacles when fully extended are inconspicuous and almost transparent. The colours of the living coralla of this species are usually light; in some examples observed, a delicate cream colour predominated; in others, collected on the Palm Islands reefs, a pure pink, or light yellow, with pink septal ridges, were equally mingled; while in a third series the coralla were entirely buff, with the exception of a white border to every folium or elevated frill. Coloured illustrations of this species are furnished by Figs. 9 and 10 of Chromo plate No. VII.

The genus Hydnophora may be said to represent a more pronounced development of the peculiarities of Merulina. In this generic group the coralla are composed of either solid masses or foliaceous expansions, which may be raised in the form of simple or more or less branching tufts, while the septal systems are concentrated together in such manner as to form, collectively, minute conical elevations that are distributed evenly throughout the surface of the corallum. In one species, apparently identical with the *Hydnophora rigida*, collected by the author at the Palm Islands, delineated in Fig. 8 of Chromo plate No. VII., the corallum assumes an erect branching character resembling that of an ordinary Stags'-horn coral, Madrepora, for which, indeed, it was at first sight mistaken. The record of this species as a Great Barrier type is of interest, since, from the time of its earliest discovery by Dana, in the Fijis, it has been lost sight of, and has occupied an uncertain position in the classificatory systems of Milne Edwards and other zoophytologists. There are circumstances associated with the structure of the polyps and their

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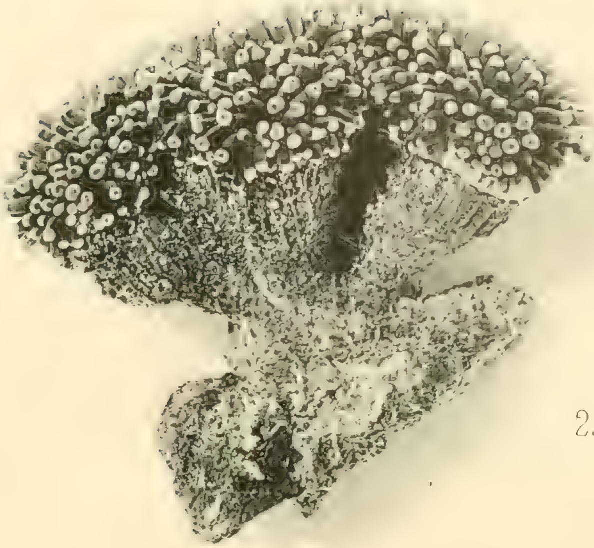

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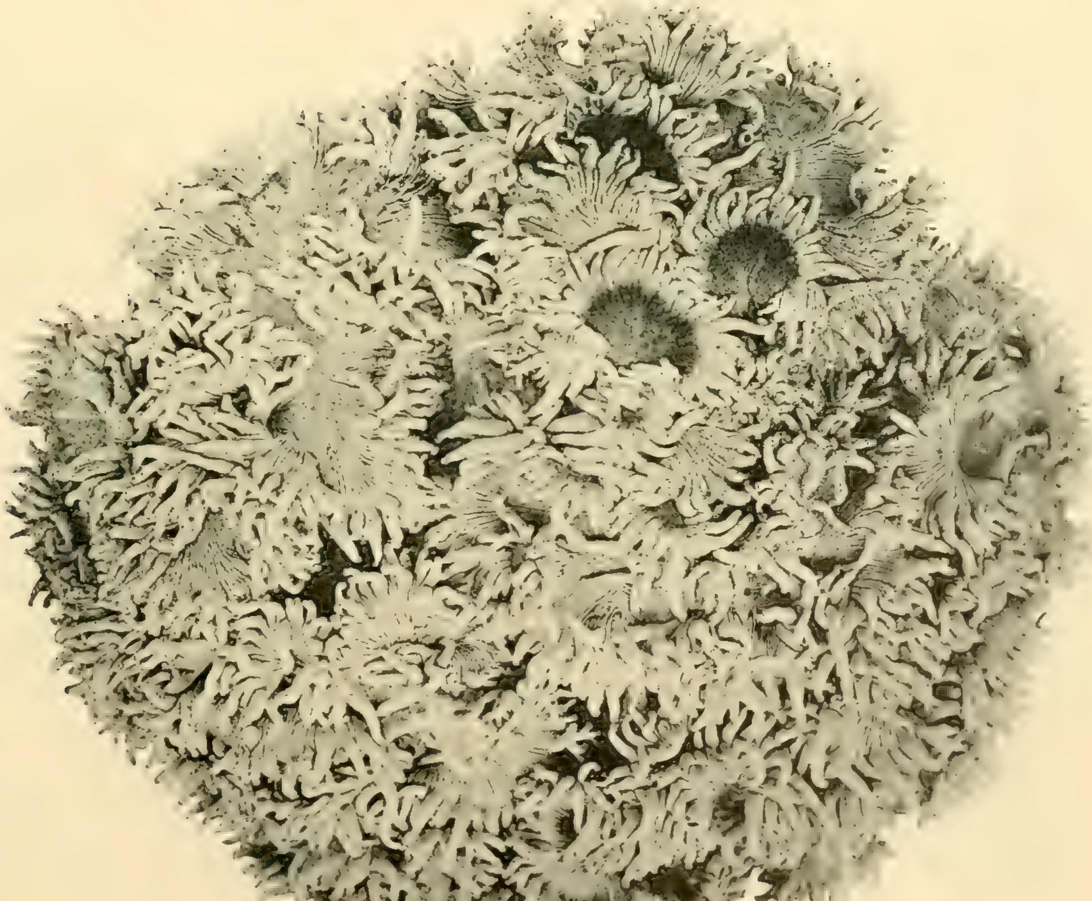

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W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

LIVING CORALS, WITH EXPANDED POLYPS.

relationship to the conical elevations of the substance of the corallum in this species, and in another obtained from the Barrier district, that may render its relegation to a separate genus desirable. In both this and the second form referred to, the oral apertures of the living polyps are distinctly associated with the summits of the conical elevations, and the surrounding tentacles are very distinctly capitate. In *Hydnophora microcona* and *H. Demidoffi*, on the other hand, the oral apertures occupy the centres of the depressions betwixt the elevated cones, and the tentacles are subulate and very attenuate, communicating to the living corallum, when the polyps are fully extended, an almost hirsute appearance. The differences indicated will be readily apprehended by a reference to the Figs. 7, 8, and 13 of the Chromo plate No. VII., illustrative of this genus. Should a separate generic title be required for the distinction of the capitate-tentacled species, the one of Monticulina, formerly conferred by Lamarck on certain members of this generic group, might be appropriately revived.

Respecting the life colours of the Hydnophoræ, there is some little latitude of variation. In *H. microcona*, Chromo VII., Fig. 12, obtained from the Mid-Barrier Reef, near Adolphus Island, Torres Strait, in which the corallum forms massive undulating hillocks, the general ground colour, and that of the polyp tentacles, is brilliant grass-green, and the conical septal elevations are light brown. In another form, *H. Demidoffi*, from the same district, in which the coralla, beginning as an irregular encrustment, are subsequently elevated into crests, cones, and ridges of divers fantastic shapes, the ground colour is a pale chrysoprase, or jade-green, and the septal elevations and polyp tentacles are light brown. In the arborescent Palm Islands type, *H. rigida*, first described, the ground colour is creamy-white, and the distinctly capitate tentacles are either pale lemon-yellow or the lightest emerald-green.

The exceptional, arborescent, species of Hydnophora last referred to, prepares the way for the consideration of that series of the aporous Madreporaria, in which an arborescent or more or less branching type of structure represents the normal growth. One family, that of the Oculinidæ, most abundantly developed in the West Indian coral seas, but rarely occurring among the Great Barrier reefs, forms erect branching coralla, whose shrub-like aggregations may be two feet or more in diameter. The substance of the corallum in the typical members of this family is remarkable for its pure whiteness and great density; and, but for the almost obliterated perforations through it, that represent the polyp centres, it would take a high polish, and might be turned to profitable account for the manufacture of articles of jewellery. It is remarkable that only a single representative of this group, in some respects resembling *Oculina Petiveri*, but apparently a new species of the genus, was personally obtained by the author, and this one was peculiar to the locality of the Barrier district. The type in question grows in some abundance, and is just accessible by wading, at lowest spring-tides, on the fringing reef of one of the Palm Islands series, known as Orpheus Island. The coralla of this Oculina, as they grow *in situ*, are very attractive objects, forming dense bushes of considerable dimensions, the general ground

colour of which is a bright golden-yellow. The thickly interspersed projecting polyp centres, together with their circlets of numerous subulate expanded tentacles, are a bright purplish-pink. A coloured representation of this interesting type will be found in Chromo plate VII., Figs. 4 and 4A. It is highly characteristic of this species that the branches of the coralla exhibit a very marked tendency, in addition to anastomosing at all distal points of contact, to fuse together laterally in such manner as to form dense fasciculi. The distal or growing terminations of the branches also are usually much compressed, and are not unfrequently somewhat triquetrous. With reference to the previously observed distinctive feature, it is proposed to associate this species with the technical title of *Oculina fasciculata*. A fragmentary branchlet of a second species of Oculina was obtained by the author from one of the pearl-shell divers in Torres Strait, at a depth of about seven fathoms. Its nearest affinities, as worked out with the assistance of Mr. Brook, would appear to be with the *Oculina arbuscula* of Agassiz, a manuscript title associated with a species from South Carolina, of which a most excellent figure, but no technical diagnosis, has been so far published. As attested in a preceding chapter (*ante*, p. 72), many of the Oculinidæ, including such genera as Lophohelia and Amphihelia, are essentially deep-water corals, and form off the European coast, at a depth of several hundred fathoms, banks that may be acres or even miles in extent.

The genus Echinopora includes three or four Barrier Reef species, one of which possesses a solid semi-arborescent corallum, somewhat resembling that of an Oculina, while in the remaining species the coralla consist of erect foliaceous expansions, comparable with those of Merulina. A conspicuous feature of all species of Echinopora is the sharply-pointed exsert character of the septa, and the more or less spinous or echinulate nature of the raised ridges or costæ that occupy the intermediate areas between the polyp-cells. In the single semi-arborescent specimen of *Echinopora horrida* (Chromo plate VII., Figs. 5 and 5A), collected in the reef adjoining the Sisters Islands in Torres Strait, the ramifying stem was in its thickest part about an inch in diameter, and of a golden-brown hue, while the tentacles, as observed only in their semi-expanded state, were dark blue. From the Palm Islands reefs, a little to the north of Townsville, two highly characteristic species of the foliaceous race of this genus were obtained. In one of these, *Echinopora rosularia* (Chromo VII., Figs. 6 and 6A), the foliaceous coralla are erect and of such extreme tenuity that in their bleached condition they appear to be constructed of paper. The ground colour of this coral in its living state is most usually a golden-brown ; but it is not unfrequently variegated towards the bases of the inner surfaces of the corallum with shades of dark green. The polyp-cells are developed in the form of small, raised, circular rosettes, throughout the inner surface of the folia, and, together with the tentacles of the associated polyps, are a distinct purplish-pink. This species, in Milne Edwards & Haime's *Histoire des Coralliaires*, is somewhat inexplicably associated with the two habitats of the Seychelles Islands and Van Diemen's Land. The specimens assigned to the last-named locality were probably originally collected from the

Australian Barrier. The second species of Echinopora exhibiting a similar foliaceous, but more robust and procumbent, growth-plan, and also collected on the Palm Islands reefs, would appear to be identical with *Echinopora aspera.* This species forms extensive prostrate or encrusting folia, the surface of which, including both the polyp-cells and the intervening areas, is coarsely dentate or serrated. The general ground colour of the corallum of this Echinopora is, as in the preceding species, golden-brown, more or less variegated with green. The corallites or p olyp-cells are considerably larger, being over half an inch in diameter ; the oral area is coloured a bright brick-red ; and, between this and the outer septal border there intervenes a conspicuous band of brilliant green. This specific type has been collected by the author at Port Darwin, in the northern territory of South Australia.

A trio of genera, coinciding with one another in the erect bush-like character of their coralla, and more especially in the fact that their polyps are structurally identical, although not usually included in the same family, may be conveniently treated together in these pages. The three genera in question are those of Seriatopora, Stylopora, and Pocillopora. The first-named of these is characterised by its bush-like aggregations, being composed of slender cylindrical stems that for the most part increase in height by continual bifurcation, and freely unite, or anastomose, at every point of contact with the neighbouring branches. The polyp-cells or corallites are very minute, circular, and arranged in symmetrical longitudinal series throughout the extent of the branchlets. The polyps, which are so small that a pocket-lens is required for their perfect observation, possess only twelve tentacles, which are short and very distinctly knobbed. The coralla of the living colony-stocks of both this and the succeeding genus, Stylopora, are among the most brilliantly coloured that occur throughout the coral class. The prevailing tints are a bright rose-pink, or even magenta, the colours being most intense towards the exposed distal extremities of the branchlets. The hidden, basal, portions are, on the other hand, usually light fawn or buff, with which less striking colours the entire corallum may occasionally be tinted. The minute, twelve-tentacled polyps are usually a lighter shade of the same tint as the corallum, the inflated tips of the tentacles being somewhat the brightest. A characteristic illustration of the conditions of growth of Seriatopora is furnished by Plate VIII., No. 1, of the photo-mezzotype series, representing a Port Denison reef-scape. In this illustration two colony-stocks of the pink variety of *Seriatopora elegans* or *S. hystrix*, one of them largely uncovered by the tide, occupy a sub-central position somewhat towards the left hand. Representations of a small corallum, a branchlet, and the extended polyps of a living corallum of the same species, are included in Chromo plate VII., Figs. 1, 1A, B, and C. A short, thick, acuminately-branched representative of this genus, also obtained from the Barrier district, would appear to be identical with *Seriatopora octoptera.*

In the genus *Stylopora*, both the colouring of the living coralla and the structure of the contained polyps are precisely identical with those of *Seriatopora.* The essential distinctive

characters possessed by Stylopora are the irregularly lobate and usually compressed contour of the coral branchlets, and the distribution of the polyp-cells promiscuously instead of in serial order. The corallites, moreover, possess, in addition to the twelve septa, a conspicuously developed central style or columella. In company with those of Seriatopora, the representatives of this genus inhabit the lowest level of the tide-exposed reefs, and are among the species brought up from the greatest depths at which reef corals flourish. A characteristic fragment of a living corallum of *Stylopora palmata* is included with that of Seriatopora in Plate VII. *Stylopora pistillata* and *S. digitata* represent two other species of this genus, that have been collected by the author on the Great Barrier Reef.

Pocillopora, the third genus in the group now under consideration, differs markedly in its elements from both Seriatopora and Stylopora. In the abundant Barrier species, *Pocillopora damicornis*, or a close ally thereof, the most symmetrically hemispherical coralla, present, in their bleached condition, a not remote similitude to over-mature heads of a cauliflower or broccoli. The ramifying branchlets into which the coralla are similarly subdivided, as compared with those of Seriatopora and Stylopora, are irregular, somewhat thickened, and corrugate or angular at their extremities. The polyp-cells or corallites are also more closely and irregularly crowded, and present only rudimentary traces of the septal elements. The polyps of Pocillopora are, at the same time, indistinguishable in their external characters from those of the last-named two genera, possessing, in a like manner, twelve short, distinctly capitate, tentacles. The living colours of the coralla and polyps of the Barrier species are not so brilliant as those of Stylopora and Seriatopora. The extremities of the branchlets, and also of the included polyps, are often a purplish-pink, but more frequently of a clear brown. The distal ends and inflated tips of the tentacles are usually a darker tint of the ordinary ground colour; while, in many examples observed, the tentacle tops alone were a pale beryl-green. The commonest Australian species, *Pocillopora damicornis*, is plentifully developed throughout the Barrier district, and usually occupies a low-level position on the tidally-exposed reefs. The species growing *in situ* is included in many of the reef-views reproduced in this volume, and notably in Plates XI., XII., and XV. of the photo-mezzotype series. Fragments of coralla, with the extended polyps, are also represented in Figs. 3 to 3F of Chromo plate No. VII. It commonly happens in some instances that a small barnacle of the genus Pyrgoma, and in others a bivalve mollusc, allied to Pecten, affixes itself to the extremities of this coral, causing it to become abnormally dilated and distorted in its efforts to cover in the intruding organisms. Examples of such commensal attachment are illustrated by Figs. 3F and 3G of the plate last mentioned.

All the corals hitherto described correspond structurally with one another, in that the calcareous substance of their coralla, although often highly cellular, is not distinctly spongy or perforate. On account of this character, they have been associated with the expressive

sectional title of the *Madreporaria aporosa*. Between this group and an equally extensive one which, as the corallum is very distinctly porous, is known as the *Madreporaria perforata*, there exists a small tribe in which the septal walls, while themselves imperforate, are united to one another by a multitude of minute calcareous rods, technically termed "synapticulæ," which communicate to the coralla a semi-porous consistence. As this intermediate group is most prominently represented by what are known as the Mushroom-corals, genus Fungia, and its allies, it is most usually distinguished by the title of the Fungidæ.

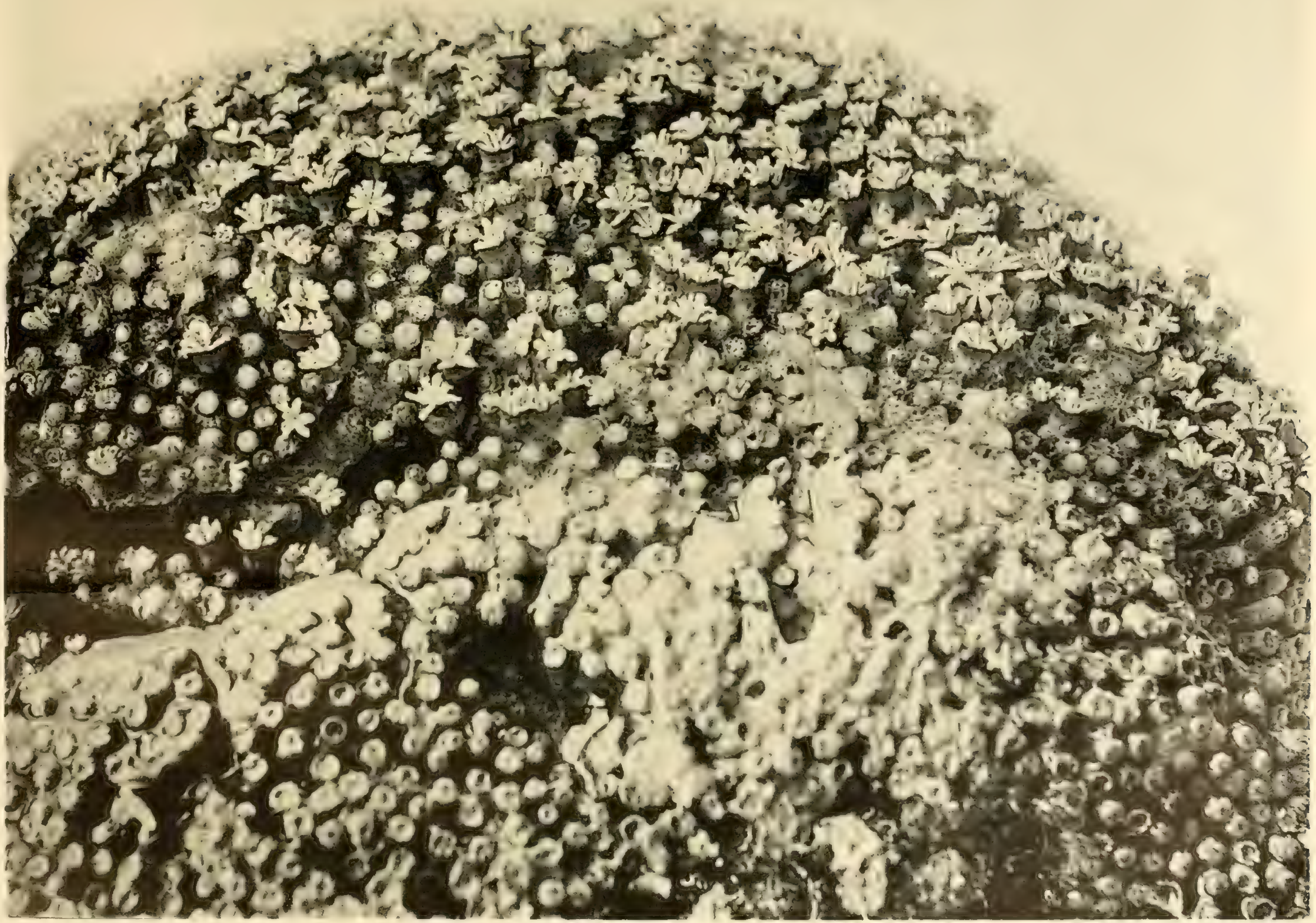
An outline of the general contour and aspect of a living Mushroom-coral has been already briefly given, in association with the descriptive texts of Plates XXIII. and XXIV. of the photographic series. In a typical representative of the genus Fungia, as illustrated by *Fungia crassitentaculata*, the subject of Plate XXIII., the corallum is subcircular or ovate, and flattened on its under surface; on the upper (and usually more or less convex) one, it is traversed by the concentrically radiating septal plates which, when denuded of their investing membrane, bear a marked resemblance to the so-called gills of a mushroom. These Fungiæ are what are known as solitary corals, each corallum consisting of a single individual corallite, which, with the investing polyp, closely resembles in its fully-expanded state an ordinary skeletonless sea-anemone, such as the common British Dahlia-anemone, *Tealia crassicornis*. Of the many species of Mushroom-corals that are to be found upon the Barrier reefs, the one, *Fungia crassitentaculata*, figured in the plate above referred to, is undoubtedly the most noteworthy. In the living state, its thick, massive tentacles, when fully extended, project to a length of two or three inches beyond the margin of the corallum, whose presence is completely hidden by the investing membrane and mass of tentacles developed from the oral disk or peristome. In colour, the tentacles of the species range, in different individuals, through every shade of bright apple-, grass-, and olive-green, and again through various shades of light, dark, and golden brown. The extremities of the tentacles among all the varieties are usually white or light grey or yellow, and are more or less distinctly inflated. Radiating striæ, generally of a yellow tint, usually mark the course of the principal septa on the investing membrane, and are continued inwards until they join the oral aperture. A characteristic illustration of the aspect of a living, fully-extended example of this species is afforded by Fig. 13 of Chromo plate No. VI., which represents a reproduced print from the original photograph, coloured from life.

The handsome species of Mushroom-coral now under notice occurs most abundantly in the northern or Torres Strait district of the Great Barrier system, and is sometimes so plentiful in the sheltered lagoons left by the receding tide, that, where the green-tinted variety predominates, they appear to be richly carpeted with a vivid green vegetation. The inflated, fully-extended tentacles, in point of fact, bear a considerable resemblance to a crowded growth of the common green seaweed, Enteromorpha. The adult Mushroom-corals repose freely on the sea-bottom; but it is interesting to observe that in their early

stage, and until attaining the dimensions of an inch or more in diameter, the coralla are attached to a rigid stalk, after the manner of an ordinary mushroom, with the gills developed on the upper surface. An illustration of this interesting development of *Fungia crassitentaculata* is furnished by the upper right-hand corner figure in Plate XXIII., and also by Fig. 14 of Plate VI. of the chromo-lithographic series, wherein two young Fungiæ are growing from a single stalk. Soon after attaining to the dimensions illustrated in the photographic figure, the young Mushroom-coral becomes detached, and falls to the ground, in most instances leaving the stalk or stolon, it would appear, to develop a new bud. On account of its essentially reproductive functions, the stolon is usually denominated a "nurse stock." This interesting chapter in the life-history of the Mushroom-coral is of high biological significance. It gives the strongest possible support to the assumption that all the existing free Mushroom-corals sprang from an ancestral type that was permanently stalked, in the same manner as it is assumed that the existing feather-stars, Comatulæ, which still in their early youth pass through a temporary stalked condition, sprang from primæval permanently-stalked Crinoids.

Another point worthy of note has to be recorded, in association with the photographs obtained from living specimens of *Fungia crassitentaculata.* The minds of biologists have been considerably exercised within the last few years by the recognition that throughout an extensive series of sea-anemones, and other Actinozoa, there is a marked tendency for the single elongated mouth to become differentiated in such a manner, that it subserves the purposes of the double incurrent and excurrent apertures of the higher invertebrata, and represents, in point of fact, the primitive or ancestral prototype of the oral and anal apertures. By so early an authority as the late Dr. P. H. Gosse, author of the classic treatise on "British Sea-Anemones," 1860, the presence of an imperfectly-closed tube or groove, at one of the opposite mouth angles only, or at both, and thence continued down the side of the throat or stomodæum, was recognised and described in association with the title of the "gonidial groove." Its particular import, however, was not discovered by this actinologist, who assigned to it the possible function of an oviduct. Later investigations, while confirming its presence throughout a very extensive series of Actinozoa, elicited the fact that its lining was beset with larger and stronger cilia than the adjacent surface of the stomodæum, and that the tube, under stated conditions, constituted a very efficient incurrent channel, and obviously fulfilled a respiratory function. When, in fact, respiration is in active operation, the borders of the elongated mouth of the Actinian are usually brought together throughout a greater or lesser extent of their median area, such local occlusion producing the phenomenon of the two apertures, the one fulfilling an incurrent and the other an excurrent function. As this groove is a highly specialised functional organ, the distinctive title of the "siphonoglyphe" has been conferred upon it by Dr. S. J. Hickson.*

* "On the Ciliated Groove (Siphonoglyphe) in the Stomodæum of the Alcyonaria." *Phil. Trans.* Part III. 1883.

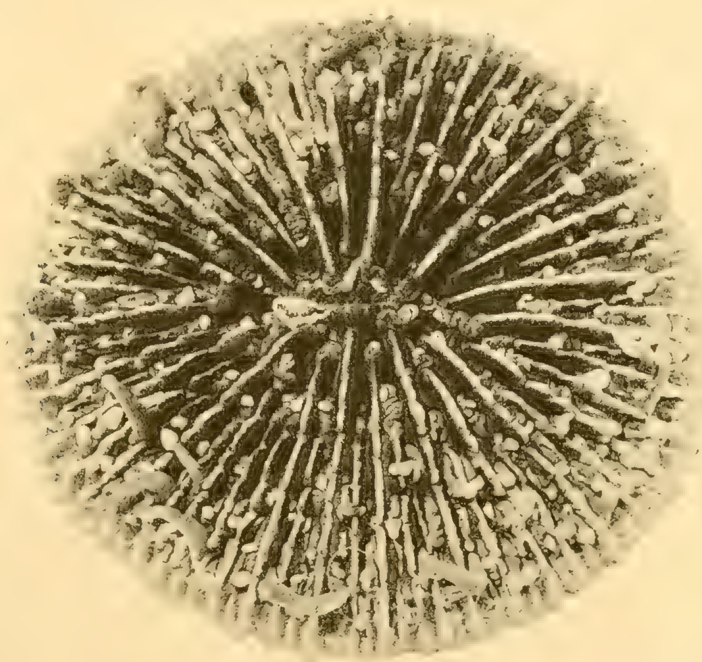


W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

ORGAN-PIPE CORAL, WITH EXPANDED POLYPS.

A more remarkable and (if tenable) far-reaching significance had yet to be associated with this readily-extemporised respiratory organ of the sea-anemone. As first pointed out by the late F. M. Balfour,* the primitive condition of the oral and anal apertures of the generalised type, Peripatus, and several other invertebrata, is that of a continuous, slit-like opening which, by the occlusion of the central area, becomes differentiated into two independent apertures, the incurrent and excurrent pores, or mouth and vent. The hiatus that previously appeared to separate the cœlenterate organism, as represented by an Actinian, from all the higher animals, was thus effectively bridged over; and the Actinia, *per se*, advanced to a position of closer structural community with the higher Invertebrata.

So far, only a few of the Madrepores, or Stony-corals, have been proved to possess the important structure denominated by Dr. Hickson the Siphonoglyphe. In the case of the Fungia



PHOTOGRAPHED FROM A LIVING EXAMPLE OF *Fungia crassitentaculata*, EXHIBITING THE MOUTH CLOSED, WITH THE EXCEPTION OF THE TUBULAR PASSAGE, SIPHONOGLYPHE, IN THE LEFT VENTRAL GONIDIAL ANGLE.

investigated by Mr. G. C. Bourne, its presence, while suspected, was not traced, although the animals were observed to close the middle portions of their mouths, leaving small apertures at the extreme ends, through which currents of water passed in and out. While looking through the supplementary photographs taken of *Fungia crassitentaculata*, the author's attention was directed by his friend, Professor G. B. Howes, to one example, in which the existence of the siphonoglyphe is very clearly recorded. This photograph is herewith reproduced. In addition to illustrating the

* Cf. Adam Sedgwick "On the Origin of Metameric Segmentation, and some other Morphological Questions." *Quart. Jour. Micr. Sci.*, XXIV., 1884.

living aspect of this organ, or, more correctly, its external orifice, with remarkable distinctness, it indicates, with greater clearness, perhaps, than the photographic reproductions previously referred to, the close association of each of the more or less contracted tentacles with the internal edge of a septal element. The distinct enlargement and lighter coloration of the distal terminations of several of these tentacles, is particularly well defined in this figure.

There are few, if any, of the Mushroom-corals that possess such relatively large tentacles as those of the species just described. It has, moreover, been the remark of a leading authority on corals—Mr. J. D. Dana (*Coral and Coral Islands*, p. 46)—that in all the species observed by him the tentacles were small and rudimentary. *Fungia crassitentaculata* was, apparently, not represented on those reefs among the Pacific Islands with which Mr. Dana made himself acquainted. So far, nevertheless, as the remaining Barrier Reef varieties are concerned, Mr. Dana's experience can be confirmed. Some half-a-dozen species, in addition to the one already named, were obtained by the author from the Barrier district; and in all of them the extended tentacles were relatively small and inconspicuous, in many instances presenting the form, only, of small triangular points. One such small-tentacled Fungia, *Cycloseris cyclolites*, is represented in profile by Fig. 16 of No. VI. of the chromo-lithographic plates. The earlier-stalked, or sessile, young of several of the above-named Mushroom-corals, were collected by the author. As notable among these may be mentioned a species closely allied to *Fungia discus*, of which an example was collected at Stone Island, Port Denison, in which no fewer than eleven young Fungiæ, of different ages, were found attached to a single dead parent corallum. A photographic illustration of this remarkable specimen is reproduced in Plate XXIV.

A gradual transition can be distinctly traced, from the simple Mushroom-corals, to representatives of the same family which present as high a degree of aggregated complexity as any of the Astræaceæ previously described. Beginning with the simple elongate Fungiæ, such as *F. echinata* and *aspera*, having single oral openings, the first step in the direction of a compound corallum is met with in the genus Cryptabacia, wherein several larger oral openings are developed along the single median longitudinal line, and a limited smaller series along each side. A further advance is accomplished in the two genera Herpetolitha and Polyphyllia, in which, while the corallum is unattached and retains the general contour of an ordinary Fungia corallite, distinct oral areas are developed equally throughout the freely exposed upper surface. Representative types of all of these intermediate genera have been obtained from the reefs of the Great Barrier system, one characteristic form, *Herpetolitha talpina*, being delineated in Chromo plate VI., Fig. 17.

Highly specialised compound corals are not wanting in the smaller group now under consideration, in which the coralla are attached, and present the massive, encrusting, or foliaceous types of growth, previously enumerated and illustrated in association with the comprehensive section of the Astræaceæ. Encrusting and foliaceous growths, combined, are abundantly typified in the genus, Lophoseris. One species referable to this genus, *L. cristata*, is so plentiful on the

fringing reefs of Stone Island, Port Denison, as to represent, locally, the chief living coral-constituent of the reef. The important position occupied by this species, in the locality referred to, is well exemplified in the photographic reef-view reproduced in Plate X., No. 2. As indicated in this illustration, the growth-plan in this species takes the form of erect vertically compressed folia, which coalesce with one another at various angles, and so constitute encrusting masses of indefinite extent, which, on account of their peculiar structure, possesses great rigidity combined with apparent lightness. The living colony-stocks of the Port Denison growths of this Lophoseris, as represented in Chromo plate VII., Fig. 11, usually possess a ground tint of cream or light-stone colour, the polyp centres being represented by pale green or lemon-yellow radiating stars; the polyp tentacles, when extended, correspond in colour with the septal radii. In other localities, such as Adolphus Island, Torres Strait, and elsewhere, the living coralla of an allied but more massive species, *Lophoseris crassa*, observed by the author, were a rich golden-brown, and the radiating centres and extended polyps bright grass-green.

The third generally recognised subdivision of the Stony-corals, known as the *Madreporaria perforata*, includes all those forms in which the calcareous substance of the corallum is of a distinctly porous nature. In its variety of species, and in the numerical abundance and dimensions of the individual colony-stocks belonging to this group that enter into the composition of the Great Barrier coral-reefs, it claims equal rank with the tribe of the Astræaceæ previously described. On many of the tidally-exposed reefs, as a matter of fact, its members monopolise by far the largest area of the visible reef-scape; and in one genus, Porites, they represent the foundation of the outer breastwork of the reefs that are exposed to the full brunt of the raging breakers.

Beginning with the simplest, and proceeding in the direction of the more complex members of the group, there are several *Madreporaria perforata* that correspond with an ordinary Mushroom-coral, in that they are the equivalent of a single individual polyp. In one of these, the genus Balanophyllia, which has a British representative, the corallum is short, subcylindrical, and permanently rooted to the coral-rock or other selected fulcrum. In an allied Great Barrier type, *Heteropsammia Michelini*, the corallum is remarkable for attaching itself in the earliest stage of its growth to the shells of small gasteropodous molluscs, which, in course of time, it completely enshrouds with the substance of its corallum; and thenceforward it exists as a sub-globose independent coral, of about three-quarters of an inch in diameter. This generic form necessarily plays no material part in the process of reef construction; and it is usually procurable only with the assistance of the dredge. It has been collected by the author both in Cleveland Bay, off Townsville, and in the neighbourhood of the Capricorn reefs; and an illustration of this somewhat singular type, in which the polyp tentacles are fully extended, is given in Fig. 12 of Chromo plate VI.

A coral whose corallum may be said to represent a compound, arborescent, growth of a simple Balanophyllia, is illustrated by the genus Dendrophyllia, of which two species are met with in the Barrier district. One of these, *Dendrophyllia axifuga*, Chromo plate VIII., Fig. 4, may be gathered occasionally on the reefs in Torres Strait at extreme low tide; but it occurs much more plentifully in deeper water, where it commonly grows on the large mother-of-pearl shell, *Meleagrina margaritifera*, systematically collected by the divers. In its living state, the corallum of this species is light golden-brown with a slightly greenish tinge. The tentacles of the extended polyps, which are numerous and attenuate, are primrose or lemon-yellow, and the oral centres a purer shade of the same tint. The second species, *Dendrophyllia coccinea*, Chromo VIII., Fig. 1, has been obtained more rarely by the author, under overhanging ledges of coral-reefs in the neighbourhoods of both Thursday and Warrior Islands, in Torres Strait, and, in both instances, in almost inaccessible positions, more or less completely screened from the access of daylight and very rarely exposed to atmospheric influences. Notwithstanding its isolation from light, the colours of the living corallum and associated polyps of this species are abnormally brilliant. The entire surface of the corallum, and the membrane surrounding the oral orifice, are a bright brick-red, approaching vermilion; while the extended tentacles, which form a circlet of about forty-eight individual, elements, representing five cycles, are elongate, subcylindrical, distinctly granulate and of a bright-orange hue. It is worthy of note, before taking leave of the family of the Eupsammidæ, that its members are among the least prominent of reef-constructors. Many of its solitary representatives are found in temperate and abyssal seas, two species, *Balanophyllia regia* and *Stephanotrochus Moseleyanus*, being denizens of British waters. The second generic type, Dendrophyllia, is represented in the Mediterranean by the large arborescent species *Dendrophyllia ramea*, which form was dredged by the author off Setubal, on the Portuguese seaboard, from a depth of 600 fathoms, in the year 1870, in company with *Lophohelia prolifera*, *Amphihelia oculata*, *Hyalonema lusitanicum*, *Pheronema Grayi*, *Askonema setubalense*, and other deep-sea sponge and coral types. The most remarkable fact connected with the deep-sea specimens of *Dendrophyllia ramea* was that the corallum and polyps, when brought to the surface, possessed, in their living condition, the same brilliant red and orange tints that characterise the shallow-water Barrier Reef type above described.

The members of the *Madreporaria perforata* pertaining to the family of the Eupsammidæ here enumerated, accord with one another in that their individual corallites are relatively large, commonly measuring half an inch in width, and not unfrequently more. In the family group that next offers itself for consideration, that of the typical Madreporidæ, represented by the genus Madrepora and its near allies, the individual corallites are of almost microscopic minuteness; and, if the single larger terminal calicle that characterises the growing extremities of certain species be excepted, they rarely exceed one-eighth of an inch in diameter.

The genus Madrepora represents the most extensive existing natural group of closely-allied specific forms included in the coral class, and may in this respect be appropriately compared with the specifically rich botanical genera, Rosa or Salix. As in the case of the botanical groups, considerable difficulty attends the definition of the slightly-varying structural characters that serve to distinguish the more nearly allied types, of which over two hundred varieties have been described. The determination and identification of the number of species—no fewer than seventy—that were collected by the author in the Great Barrier district proved by no means a sinecure to the authority, Mr. George Brook, F.L.S., to whom they were consigned for incorporation with the British Museum collection. Out of this considerable number, fourteen have proved to be absolutely new species, while some ten or twelve others represent co-types now described for the first time, in association with duplicate specimens recently received from other localities of the Indo-Pacific area. The enumeration of the characters of the seventy specific forms obtained from the Great Barrier district lies outside the purpose of this volume. A brief notice of some of the more conspicuous species can alone be attempted.

As an aid towards the accomplishment of their systematic nomenclature, it is found convenient to arrange the numerous specific forms of the genus Madrepora into sections, whose respective members correspond with one another in the characteristic growth-pattern of their coralla. Thus, in one numerically abundant series, the coralla are distinctly arborescent, consisting of lax irregularly-branching growths which, with reference to their more or less distinct, antler-like contour, are popularly known as "Stags'-horn Corals." In a second series, the branching coralla are so closely aggregated as to form symmetrical, shrub-like clumps. In a third group, the base of the corallum expands in the form of a vase, the upper surface of which gives origin to the short, polyp-bearing secondary branchlets. In a fourth series, the branches either exhibit a bluntly lobate contour, or may be flattened out in the form of broad folia. These suggested sectional divisions are necessarily artificial, and are introduced only for the purpose of facilitating specific identification; as they actually exist in nature, they are intimately interwoven with one another through the interposition of connecting types.

A feature that is common to all the numerous specific forms of the genus Madrepora is represented by the structure of the associated polyps. These are of a very simple type. They possess only twelve tentacles, and twelve mesenteric and septal cycles, or "sarcosepta" and "sclerosepta," as they are technically designated. It is remarkable, however, that in not a few of the specific varieties, one of the tentacles is invariably of abnormal size, being twice the length of any other. It also commonly happens that the single terminal or growing corallite, and the associated polyp, at the extremity of each branch or branchlet, is conspicuously larger than those of the lateral series. This abnormally large terminal corallite and polyp, together with all the adjacent ones that enter into the composition of the growing apices, differ, very frequently, to a marked degree in colour from those of the preceding or more proximal area.

Taken collectively, the tints of the living coralla and polyps of the species of Madrepora are among the most brilliant in the coral class, and they abound with remarkable combinations. It is further noteworthy that local colony-stocks of the same species may be of conspicuously distinct tints. Finally, it has fallen within the writer's experience that the same colony-stock may undergo a distinct change in colour of both its corallum and polyps, within a more or less brief interval of time. The following was observed of a luxuriant patch of *Madrepora hebes* growing in a coral reef pool in Vivien Point, Thursday Island, utilised by the author for experimental cultivation of the mother-of-pearl shell, *Meleagrina margaritifera.* When first noted, in the month of September, 1889, the corallum was of a pinkish-brown hue, with greenish-white growing apices; while all the polyps, with the associated tentacles, were a light emerald-green. The coloured sketch then made of a branch is reproduced in Chromo plate IX., Fig. 15, with a magnified view of the extended polyps. No particular notice was taken of this coral colony on revisiting the locality in the subsequent year, excepting that it was observed that its growth appeared to have been greatly retarded. On re-examining it, however, in August, 1891, it was found that the corallum was of a clear seal-brown hue, with white, and in some instances pale lilac-blue, tips, while all the polyps were a clear red-brown, with greenish-white tips only to the extremities of the tentacles. All the emerald-green tints that so conspicuously distinguished the extended polyps two years previously had entirely disappeared. The phenomenon above recorded suffices to prove that colour cannot be accepted as yielding a reliable diagnostic character for the specific distinction of closely allied coral types. As here demonstrated, it is not only subject to variation among separate colony-stocks of the same species, but it may vary at different epochs in the same colony. The variety, *Madrepora hebes*, now under consideration, belongs, as will be recognised by the illustration already named, to that series in which one (the lowermost) tentacle is abnormally prolonged. In the larger, terminal, or growing, corallites of the same species, it was observed that the polyps did not exhibit the same radial symmetry of their tentacles that characterised the adjacent individuals, two or three abnormally elongate tentacles only being exserted from the calicinal orifices. A similar structural peculiarity has been observed by the author in several other species of the same genus.

An enumeration of the more remarkable colour variations of the living coralla and the associated polyps of the Barrier Reef Madreporæ, may now be proceeded with. The Stags'-horn variety, *Madrepora hebes*, already referred to, while most commonly dark-brown with white extremities, may, in some instances, including both the corallum and polyps, be entirely a vivid grass-green. This green variety may have white or bright lilac extremities to all the branchlets, as shown in Chromo plate IX., Fig. 13; or the corallum may be bright lilac throughout. A typical illustration of the luxuriant growth of this Madrepora in certain localities is afforded by the photographic reef-view reproduced in Plate XII., wherein this single species, chiefly the brown, white-tipped, variety, monopolises almost the entire

landscape. Among other species exhibiting a branching, Stags'-horn, growth-plan, *Madrepora grandis*, Chromo IX., Fig. 8, is notable for the bright-yellow, pale-lemon, light-lilac, or nearly white, tint of its massive branching corallum. In a variety of the almost equally massive *Madrepora decipiens*, Chromo IX., Fig. 5, the general surface of the component branches is pale yellow, and the terminal inch or so of every branchlet, rose-pink. The prominent tubular corallites, in their respective regions, exhibit a brighter tint of the normal ground colour; the polyps in this type are greenish-yellow on the main shafts of the larger branches, and a pure canary-yellow throughout the remaining areas. In the more delicately branching type, *Madrepora pulchra*, Chromo IX., Fig. 12, the general ground colour of the corallum is light buff or yellow ochre, and the abnormally large terminal corallite, or it may be the terminal half-inch of every branchlet, a pale porcelain-blue or the most delicate lilac. The extended polyps vary on the general surface from light-brown to greenish-yellow, while those belonging to the single, lilac, apical corallite, are not unfrequently bright emerald-green. The handsome electric-blue species, *Madrepora laxa*, Chromo IX., Fig. 6, collected at the Palm Islands, has been referred to on page 111.

Between the typical "Stags'-horn" Madreporæ and the corymbose, or bouquet-shaped, varieties next described, that group may be interpolated whose coralla form bush-like clumps, composed of relatively slender, but very thickly ramifying, branches. The bleached coralla of *Madrepora rosaria* and *M. formosa*, included in Plate I. of the photo-mezzotype series, afford appropriate illustrations of this group, to which may be added the three species represented by typical branches in Figs. 11, 16, and 17 of Chromo plate No. IX. *Madrepora divaricata*, represented by Fig. 17 in the plate named, is remarkable for both the elegant contour of its corallum and the brilliance of its living tints. The bush-like corallum much resembles that of *Madrepora formosa*, photographically represented by Fig. 24 of Plate I., but differs from it most essentially in the fact that the branchlets freely coalesce with one another at every point of contact. The most characteristic hues of this species, as represented in the coloured lithograph, include a bright straw-coloured general ground tint, with the terminal half-inch shading from pale lilac, approximately, to brilliant magenta or heliotrope at the apical terminations. The two illustrations, Figs. 11 and 16 in Chromo plate IX., represent branchlets, in the former instance of *Madrepora Elseyi*, and, in the latter, a variety of the same type or the *Madrepora scabrosa* of Quelch. The brilliant grass-green *Madrepora ornata*, obtained from the neighbourhood of the Claremont Lightship, represented by Chromo IX., Fig. 4, furnishes another interesting connecting form, between the typical Stags'-horn and the spreading, corymbiform, species.

Among the species of Madreporæ that exhibit a distinct vase-shaped, or corymbiform, type of growth, an equally varied range of coloration obtains. By far the most abundantly developed and most widely distributed representatives of this particular series are known by the names of *Madrepora millepora* and *M. convexa*. The first-named type occurs abundantly throughout the Barrier district, and is one of the reef species which, until within a relatively recent date (*see* p.

96), flourished as far south as Moreton Bay. As with the Stags'-horn variety, *Madrepora hebes*, previously described, although much more frequently, these two species may occupy the greatest portion of the tidally-exposed reef-surface, covering acres as far as the eye can reach. Such a luxuriant development of *Madrepora convexa* is characteristically illustrated by the photographic reef-view reproduced in Plate IX., and to a lesser degree in Plate X., No. 2. The living colony-stocks of this species, as shown in Plate IX. consist at every stage of development, of flattened, slightly convex, expansions, and these may be several feet in diameter. The visible upper surface is composed of short, erect, subdividing branchlets, which, springing from a more or less massive basis, formed by the coalescence of the primary branches in a horizontal plane, rise approximately to the same level. The increase in size of these coralla, as shown by the specimens in the reef-view named, is accomplished by the outgrowth of the peripheral border. A type very closely allied to both *Madrepora millepora* and *M. convexa*, but having a more conspicuously flattened corallum, is distinguished by the title of *Madrepora prostrata*. Fragments of two colony-stocks of this species are delineated with their living colours in Figs. 1 and 2 of Chromo IX. As here demonstrated, the colours of the living coralla vary considerably. As they most abundantly obtain, the basal portions of the coralla, together with the greater area of the erect branchlets, one of a dark-fawn or a red-brown hue, while the distal terminations of the branchlets are pale greenish- or primrose-yellow. In other colony-stocks, the basement and erect branchlets, excepting at their tips, are either a light buff-brown or a bronze-green, the terminal half-inch or so, as in the previously-described variety, being light yellow. In rarer instances, coralla have been met with in which the basement was fawn-coloured, and the corallites a bright rose-pink, excepting those of the terminal quarter of an inch, which were bright lemon-yellow. The polyps with their extended tentacles, in this rose-tinted variety, were pale yellow throughout; in the commoner varieties, previously described, they were usually pale emerald-green. In another somewhat abnormal variety of this very variable species, the branchlets were a dark sage-green, the terminal corallites and the edges of many of the penultimate ones being crimson.

A rarer corymbose member of the genus Madrepora is delineated by Fig. 3 of Chromo plate IX. Its corallum somewhat resembles that of the species last described, but possesses larger branchlets, with more excert corallites and larger calicinal orifices. It is chiefly remarkable for its brilliant colour, both the corallum and the extended polyps being a rich violet hue throughout. This species, which is seldom uncovered by the tide, has been obtained by the author on the Warrior reef, in Torres Strait, and in the neighbourhood of the Lark Passage, a little north of Cooktown. The coral proving to be a species new to science, Mr. Brook has paid the author the compliment of associating it with his name. A photographic representation of a complete bouquet-shaped corallum of this fine species is reproduced in Fig. 21 of Plate I. An exceedingly handsome and more robust corymbiform type of the genus Madrepora, commonly distributed throughout the Barrier district, has been associated by Mr. Brook with

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

AUTHORS' METHODS OF PHOTOGRAPHING SUBMERGED CORALS AND BECHE-DE-MER.

the technical title of *Madrepora australis.* This species is abundantly represented among other luxuriant allies in the photographic reef-view reproduced in Plate XVII., and also by a single typical corallum in the centre of the "Stags'-horn" reef in Plate XII. of the same series. As there shown, the characteristic growth form of this type is that of a symmetrical bouquet, elevated and erect on a tapering footstalk. The evenly developed branchlets which form the crown of the bouquet, are of considerable thickness, an inch or more at their bases, tapering evenly to their distal terminations, and are but rarely subdivided. The terminal polyp cell of each branchlet is considerably larger than the others, and may be as much as a quarter of an inch in diameter; corallites of this size very seldom occur among the members of the genus Madrepora. The colours of the living coralla of this species are subject to considerable variation, but are in all instances conspicuously brilliant. A light cream or buff coloured base, with delicate lilac or heliotrope shades extending through the terminal inch or so of each constituent branchlet, represents the most ordinary colour pattern. Sometimes the base is reddish-brown, and the terminal corallites adjacent are a deep purple; or the corallum may be entirely bright lilac. The extended polyps in all the varieties above enumerated were lilac throughout, those in the terminal or distal regions being the brightest. The tentacles in this species are of uniform size, there being no abnormally long one as obtains in *Madrepora hebes, convexa,* and *prostrata.* Two of the erect digitiform branches of a species, *Madrepora gemmifera,* very nearly allied to *M. australis* but of a yet more robust growth, are delineated in their natural living colours in Figs. 9 and 10 of Chromo plate IX. A fine corallum of this variety, growing *in situ,* occupies the foreground to the left in Plate XVII. of the photographic reef-views. In addition to the colour variations above enumerated, the corallum of *Madrepora gemmifera* is not unfrequently brilliant lilac or magenta throughout.

One other representative of the corymbiform section of the genus Madrepora invites brief notice. This is a species, *Madrepora surculosa,* very generally included among the stock forms that are commercially collected and exported in a bleached condition for decorative purposes. The shape generally assumed by the corallum of this type is that of a shallow, widely-expanding vase or epergne, the upper, concave, surface of which is thickly beset with short, slender, sprig-like, calicle-bearing processes, which are homologous with the conspicuous terminal branchlets in the several species previously enumerated. A remarkably fine example of this highly characteristic type, associated with smaller specimens of the same species, is included in the photographic reef-view reproduced in Plate XIII.A (No. 2). As with most other species of its genus, the living coralla of *Madrepora surculosa* are subject to a wide range of colour variation. Some examples, among the more noteworthy of the colour patterns recorded, were a light primrose-yellow throughout. In a second instance, the base and substratum of the expanded crown were pinkish-buff, and the terminal areas of the sprig-like branchlets, with the outer rim of the entire vase-like expansion, straw-colour. In a third, and perhaps more commonly recurring, variety, the general ground colour was

a warm pinkish-brown, the outer edge of the expanded vase, for a width of half an inch, pale lilac, while the terminations of many of the central sprigs were pink. The colours of the expanded polyps, so far as observed, were found to correspond with those of the associated corallites.

A group of the genus Madrepora which still awaits notice is the one that includes those rarer, more massive, species, whose coralla take the form either of thick erect lobes or folia, or of corrugated incrustations. A typical representative of this subdivision is illustrated by *Madrepora cuneata*, referred to on page 105, as constituting one of the most conspicuous species on the platform reef that skirts Masthead Island in the Capricorn group. This platform is composed of a series of shallow terraces, over which the water drains in a smooth pellucid sheet, at lowest ebb. The surface of the reef, which would appear to be never completely bare of water, is almost completely encrusted with the radiating ridges and irregular nodular coralla of the Madrepora. The colour of the corallum in this species is usually light brown edged with white, and the associated polyps are of clear brown. In a very closely allied deeper-water species, *Madrepora palifera*, which builds up massive fronds or lobes, several feet in height, just outside the platform's edge, both the prominent corallites and the associated polyps are a bright primrose-yellow. With reference to the fact that there is no modified apical or terminal corallite in these massive encrusting or foliaceous Madreporæ, they have been referred by Dana to a sub-genus bearing the distinctive name of Isopora.

A genus of the Perforate corals that is so nearly allied to that of Madrepora that it is held by some authorities to represent an imperfectly developed, or a degraded modification of that generic group, is that of Montipora. The coralla in this genus commonly take the form of thin encrusting, or free, widely-expanding, folia; but they are in other instances represented by more solid masses whose surfaces are, wholly or in part, developed into a variety of lobate or tufted excrescences. The texture of the surface of the coralla of the members of this genus Montipora is generally ornamented with what may be described as a sort of frost-work of calcareous spicules, which is of extreme beauty as seen with the aid of the microscope. The pattern is different in every species, and these spicular elements furnish valuable accessory characters for the establishment of distinctions between what would otherwise appear, in many instances, to be identical varieties.

Several members of the genus Montipora enter conspicuously into the construction of the Barrier reefs; but, as they are most abundantly developed below the line of lowest spring ebb, they are rarely uncovered. A fair illustration of the typical mode of growth of the foliaceous varieties is afforded by the photographic reef-view reproduced in Plate IX., where, in the foreground, towards the right hand, a somewhat broken-up colony-stock of *Montipora expansa* is conspicuous. Other coralla of the same species occupy a position immediately beneath a luxuriant growth of *Madrepora convexa*, a little to the rear. An allied species, *Montipora foliosa*, or its near relative, is characteristically represented in the Warrior Island reef-view

photographically reproduced in Plate XI.; one erect, and another overturned, corallum, occupying a position near the centre of the middle distance. The colours of the living coralla and polyps of the Montiporæ are almost as brilliant as those of the genus Madrepora. The species illustrated in Plate IX. is usually a bright lilac, and the polyps a deeper violet. In some instances the corallum is light brown, bordered with mauve, and the polyps are dark green; and in others the corallum is brown, edged with bright yellow, and the polyps are greenish-white. In a fourth variety the general surface of the corallum is a light golden-yellow, and the associated polyps are brilliant violet. Coloured illustrations of several of the more prominent foliaceous species of the Barrier Reef Montiporæ are included in Chromo plate No. VIII. As indicated in the figures there reproduced, the living polyps in this generic group are exceedingly minute; and the tentacular elements are in most instances altogether rudimentary, and represented by mere inflated papillæ. One of the more massive species of this genus, allied to *Montipora scabricula,* is delineated in Chromo VI., Fig. 11. It forms castellated or tufted masses a foot or more high, the basal portions of which are, in life, nearly black, while the terminal areas are light brown or cream-coloured. The twelve rudimentary bulbous tentacles are usually of a clear brown.

With regard to the *rôle* played by the *Madreporaria perforata* in the task of solid reef-construction, the palm must, undoubtedly, be awarded to the genus Porites. The individual corallites and the associated polyps of the species of this genus are among the most minute of their class; but they form aggregations that in dimensions and density surpass those of any other type. One of the commonest species of the genus, *Porites astræoides,* not unfrequently builds up coralla that measure over twenty feet in diameter and as many in height, the whole fabric being the product of repeated subdivision and multiplication of a single primary polyp, of microscopic dimensions. These huge, massive, Porites grow in the deep water on the outer edges of the reefs, and commonly form a basis for smaller, higher-level, corals. Instructive illustrations of the plan of growth of these massive forms are afforded by the photographic views that constitute the lower figures of Plates Nos. V. and VI. In the latter of these, delineating a portion of the fringing reef of the Greater Palm Island, the irregularly lobate masses of the Porites show indistinctly beneath the water-level, and are surmounted by a luxuriant colony of other coral species, including members of the genera Goniastræa, Symphyllia, Madrepora, Mussa, and Cœloria, many of which are themselves of considerable dimensions. The long diameter of this huge Porites corallum is not less than thirty feet, and the depth of water along the edge exposed to view is over two fathoms. A corresponding growth of this same species of Porites is illustrated in the reef-views reproduced in the upper figures of Plates VI. and X. of the same phototype series. The substratum of the reef on the outer end of Vivien Point, Thursday Island, illustrated by Plate II., and referred to at some length at pp. 7 *et seq.*, in connection with systematic measurements

(recorded with the object of ascertaining the rate of growth of the associated corals by hereditary observation), is likewise composed of the same species of Porites.

In addition to the massive-growing representative of the species just described, there are many other varieties of Porites, indigenous to the Barrier Reef. Some of these exhibit, on a smaller scale, a similarly solid habit of growth; while others construct coralla which may be irregularly lobate, digitate, or even arbuscular. The coralla of the two last-named growth-types considerably resemble those of the imperforate genus Stylopora; and it is noteworthy that the living polyps of all the representatives of the genus Porites examined by the author, agree structurally with those of Stylopora, their tentacles being twelve, and distinctly knobbed or capitate at their extremities. This fact is of interest, as demonstrating that the classification of the coral class on the basis of the structure of the corallum alone is to a large extent empirical, and fails to bring into close alliance many forms that are naturally related to one another by virtue of the similarity of their soft parts.

The colours of the coralla and the associated polyps are, in the genus Porites, neither as varied nor as brilliant as are those of the two genera previously described. A light ochre, dark and golden or mustard yellow, and brown, are the prevailing hues among the arborescent types. The surface of the corallum in the massive species, however, is often a delicate pink, a light or bright lilac, or (more rarely) pale yellow. The abnormally large massive block represented in the Palm Island reef-view, Plate VI., was of a pinkish-lilac hue, as were many coralla belonging to the same species in that district. The living polyps, as above mentioned, possess twelve tentacles, the extremities of which are distinctly inflated. While the oral disks and bases of the tentacles usually correspond in colour with the corallum, the inflated tops of the tentacles are most frequently greenish-grey. Coloured representations of three typical forms of the genus Porites, with enlarged delineations of their associated polyps, are included in Chromo plate No. VIII.

The genus of perforate corals that invites attention next to Porites is that of Alveopora. In this generic group the component cells of the corallum, or corallites, are of larger size than those of Madrepora, Montipora, and Porites, resembling somewhat, in their close approximation to one another, the cells of a honeycomb. In texture, these corallites are of exquisite tenuity, as though constructed of delicate lacework; while the septal elements, which in the majority of corals are represented by distinct plates or lamellæ, are in this genus replaced by simple spinous processes. The contour of the coralla in the genus Alveopora is usually more or less rounded or deeply lobate. In one variety, however, allied to *Alveopora clavaria*, dredged by the writer in the neighbourhood of the Lark Passage, the corallum exhibits a sub-dendroid type of growth. In the sub-globose or irregularly lobate variety of *Alveopora viridis*, that occurs in some abundance in the neighbourhood of Thursday Island, the polyps are usually a bright apple-green or primrose-yellow, sometimes varied with a little brown. In another Barrier species, *A. spongiosa*, the polyps are

clear liver-brown throughout, with the exception of white tips to the tentacles. The tentacles, which are invariably twelve in number, are in their most characteristic extension, inflated at their extremities. Representations of the living coralla and polyps of two of the afore-named species are included in Chromo plate No. VIII., while the growing coralla of *Alveopora viridis* form conspicuous objects in the foreground of the photographic reef-view No. XXXIII.A.

A genus of the Perforata, closely allied to Alveopora, is that of Rhodaræa. The corallum in this generic group, however, is of much more dense consistence, and the polyps possess twenty-four tentacles, in place of twelve only; these tentacles, moreover, are never capitate. The corallum of Rhodaræa is almost invariably hemispherical or lobate in contour, and both its surface and the associated polyps exhibit a great diversity of colour. A bright apple-green tint like that of Alveopora sometimes obtains. In other species, the polyps may be pale green with lilac-tipped tentacles, or lilac with white oral centres and tentacle tips; while in a third variety they are clear liver-brown throughout. A conspicuous colour variation of the commonest Barrier species, *Rhodaræa calicularis*, is represented by Figs. 6 and 6A of Chromo plate No. VI. In this example the protruding oral centre is bright crimson, and the surrounding peristomial area pure white; the tentacles are a deep sage-green, and the shaft or column of the extended body is light brown. A new species of this genus, *Rhodaræa fruticosa*, obtained by the author on the Warrior reef, differs from previously described allies in that the corallum takes the form of a small, erect, furcately-branching bush. The polyps of this species are clear liver-brown, with a pure white oral disk. As originally described by the author in the *Records of the Australian Museum* (Vol. I., No. 6, p. 123, 1891), this species was referred, under the above specific name, to the genus Goniopora. It is a feature common to all the species of the genus Rhodaræa, and to those of Alveopora, that the polyps in full extension protrude a long distance beyond the orifices of their individual corallites. The tentacular wreath under these conditions is mounted on the extremity of a slender, cylindrical, stalk or column, which may project for the length of an inch or more from the surface of the corallum, and, together with the attenuated tentacles, float loosely in the passing current. The fact is made clear in this association that the corallum in the Madreporaria is secreted entirely by the basal region of the polyp's body. It is worthy of note that the polyps of Rhodaræa correspond structurally with those of the aporous genus Heliastræa, in the same manner as the polyps of Porites have been shown to resemble those of Stylopora. Typical illustrations of the living coralla and associated polyps of several species of Rhodaræa are included in Chromo plate No. VI.

Among the genera of Perforate Madreporaria that remain to be noticed, Turbinaria is remarkable for the elegant cup- or vase-like contour of the coralla of its most characteristic species. When not vase-shaped, the coralla form more or less extensive smooth, or plicated, folia, or more rarely, incrusting masses. Known by the popular title of Cup-corals, two species, *Turbinaria peltata* and *T. patula*, are commonly obtained by the pearl-shell divers of Torres Strait, attached to

the mother-of-pearl shell, *Meleagrina margaritifera.* When of perfect symmetry, these Cup-corals are in considerable demand, for utilisation as card-trays or other table ornaments. The two species named differ from each other most materially in the sizes and the numbers of the polyp-cells, which are developed, exclusively, on the upper or convex surface, and on the growing marginal rim. In *Turbinaria peltata* they are relatively large and scattered, but in *T. patula* they are minute and crowded. The living corallum in the large-celled species is usually of a whity-brown tint, and the associated polyps a purer white, with greenish centres. The tentacles being numerous and simply subulate, the aspect of the corallum, with its extended polyps, is that of a vase thickly studded inside with short-stalked daisies. Occasionally, as delineated in the Fig. 12 of Chromo plate VIII., the ground colour of both the corallum and the associated tentacles in *Turbinaria peltata* is a delicate rose-pink. In the smaller-celled Cup-coral, *T. patula*, the living corallum, represented by Fig. 11 of the plate just quoted, is more commonly of a light buff or a golden-brown hue, and the polyps, which are similar in form to those of the preceding species, are brilliant yellow. There are varieties of this type in which the corallum is a delicate pink or pale lilac, the polyps being a paler hue of the same tint; while, in other instances, the ordinary, buff-coloured corallum is variegated inside with dull green. The two species of Turbinaria above described are especially plentiful in the Torres Strait district; but, being inhabitants of the deeper water, they are rarely found on the reefs. A third type, *Turbinaria cinerascens*, whose coralla commonly begin their existence in the form of a cup, and afterwards develop into variously convoluted, foliaceous expansions, is an essentially reef-growing species, and occurs abundantly in the vicinity of the Palm Islands, and at Stone Island, Port Denison. The colour of the corallum of this type, represented, fragmentally, by Fig. 14 of Chromo VIII., is almost invariably a rich golden-brown, and the polyps, as in *T. patula*, are brilliant yellow. *Turbinaria crater*, with small polyp-cells and a thin, widely-expanding, corallum, is a third species that was obtained by the author from the Palm Islands reefs.

The last genus on the list of the *Madreporaria perforata* is that of Astræopora. The polyps in this genus closely resemble those of Turbinaria; but the corallum is massive, sub-globose, or hemispherical. The polyp-cells are very deep, and devoid of a central columella and conspicuous septa. The colour of the corallum of the typical Barrier species, *Astræopora punctifera*, is usually a dark brown; but in one example, collected by the author at the Palm Islands, the base was light yellow, the top half a brilliant lilac-magenta, and the extended polyps rose-coloured. This type is represented by Fig. 13 of Chromo plate No. VIII.; but the lithographic artists have, in this exceptional instance, failed to reproduce the distinct lilac or heliotrope shade that suffused the pink of the upper surface of the corallum, and predominated at the line of junction of the pink and yellow areas here delineated.

ORDER IV.—ANTIPATHARIA.

The small order of the Antipatharia represents a group of the Actinozoa, whose position towards the previously described orders of its class corresponds very closely with that of the

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

PALM ISLANDS REEF, WITH SUBMERGED SEA-URCHINS.

Gorgoniaceæ towards the other racial groups of the Alcyonaria. The feature held in common by the two groups compared, is that they are both distinguished for the secretion of an axial skeleton or "sclerobase," usually of a dendritic or tree-like form, and of a distinctly horny or chitinous consistence. Here, however, the parallel ends. This horny axial skeleton, or corallum, is, in the case of the Antipatharia, of a denser consistence than that of the Gorgoniaceæ, while its surface, in place of being smooth, is almost invariably minutely echinate, or hispid. A more essential distinction obtains with respect to the morphological structure of the associated polyps, which in both instances form, as it were, a living bark around the axial sclerobase. In the Gorgoniaceæ hereafter described, the tentacles of the polyps are invariably eight, while among the Antipatharia the smaller number of six only is dominant, if not universal. It is on account of this normally small number of the tentacles, and of the corresponding mesenteries or sarcosepta, that the Antipatharia are placed in a separate order.

The typical species of the Antipatharia, *Antipathes arborea*, constitutes what is popularly known as black coral, and is an important article of commerce. The branching corallum in this type attains to a height of from three to four feet, the main trunk and larger branches, in well-matured specimens, measuring one or two inches in thickness. Its structure, as shown in transverse section, consists of closely aggregated concentric layers of a dense, wood-like, tissue of the colour of ebony, but susceptible of a much higher polish. An important fishery for this black coral was formerly conducted in the vicinity of Jeddah in the Red Sea, its produce finding a ready sale in the Indian market, for the manufacture of charms and amulets. This Red Sea fishery has within recent years become nearly exhausted. The development of a new field for collection would be attended with considerable profit; and such a field undoubtedly exists on the Queensland coast. Fine examples of an almost identical black coral, *Antipathes abies*, are commonly brought in to Thursday Island by the Torres Strait pearl-shell divers; and entire, or more or less fragmentary, specimens are abundantly washed up on the reefs and foreshores, as far south as the Capricorn Islands. An illustration of the Queensland black coral with its associated polyps is included in Fig. 2, 2A, and 2B of Chromo plate No. XI.

A second species of black coral, *Cirrhipathes sp. (? spiralis)*, which forms a more or less spirally twisted or simple, straight, rod-like corallum, several feet in length, is not unfrequently obtained by the pearl-shell divers in Torres Strait; and Mr. Brook has identified a specimen collected by Professor Haddon in the same locality as the *C. anguina* of Dana.

ORDER V.—ALCYONARIA.

The order of the Alcyonaria, briefly defined on a previous page, includes a considerable assemblage of polyp-animals, all of which are distinguished by the possession of eight tentacles, never more and never less, which tentacles, with rare exceptions, are fringed or pinnate.

As an order, it embraces organisms presenting as many modifications in its skeletal products as all the remaining sections of the Actinozoa. Thus, some few Alcyonaria (*e.g.*, Monoxenia, Hartea, and Haimea) are simple and skeletonless, like the simple Anemones or Actinaria. Some others, such as Clavellaria and Cornularia, correspond essentially with the sea-anemone-like polyps, Zoantharia, which, while secreting no skeleton, are united together in social colonies. The Antipatharia, distinguished by their possession of a horny or chitinous axial skeleton, are typified with countless modifications by the extensive group of the Gorgoniaceæ; while, finally, the calcareous-skeletoned Madreporaria find their equivalent in Heliopora and, in a modified sense, in Tubipora. Beyond this, the order of the Alcyonaria includes supplementary groups, such as the Alcyonidæ and Pennatulidæ, that possess no approximate analogues in the remaining Actinozoarian orders. In accordance with this very comprehensive range of modification of the Alcyonaria, it is sometimes elected to divide the entire class of the Actinozoa into two sub-sections only, of equivalent value, distinguished by the titles of the Hexacoralla and Octocoralla, or Hexactiniæ and Octactiniæ, with reference to the number of their tentacular organs and corresponding internal, mesenterial, structures. One of the moot questions among biologists at the present day, is the probable derivation of all existing Actinozoa from a primitive hexaradiate or octoradiate ancestral type. The teachings of embryology appear to suggest a decision in favour of the octoradiate or, more probably, of a tetraradiate ancestry. It is significant in this association that certain highly-specialised sea-anemones, such as Cerianthus, begin their existence with four tentacles and four mesenteries (Huxley: *Anatomy of Invertebrata*, p. 162), and that a tetrameral radiate plan is distinctive of the entire class of the simpler organised Hydrozoa, including the Hydroid polyps and jelly-fishes. Little or no consideration appears to have been given, hitherto, to these earlier tetrameral Hydrozoan affinities. The extensive, but somewhat ill-defined, Paleozoic group of the Rugosa, furthermore, is established on Madreporaria-like corals which have their septal elements disposed in tetrameral order; and one of the last scions of this ancient race, Moseleya, has, as recorded on a previous page, turned up within recent years in Australian waters.

So far as the order of the Alcyonaria enters into the composition of the Great Barrier coral-reef, its contributions are for the most part represented by that group of the typical Alcyonidæ, which is characterised by the possession of a flexible corallum of almost leather-like consistence. This corallum, on examination under the microscope, is found to consist chiefly of minute calcareous spicules of various shapes, embedded in the animal substance. Coralla of this description, on the death of the associated polyps, necessarily fall to pieces, and do not contribute substantially to the construction of the reef rocks, except, it may be, by the local accumulation of their disintegrated spicules. In the living state, however, as shown in a number of the accompanying reef-views, they may enter very extensively into the composition of the coral landscape. Before proceeding to an enumeration of the more

prominent species that belong to this, most numerically abundant, flexible series, reference may be appropriately made to two more abnormal types which, through the possession of hard calcareous coralla, lay claim to a position side by side with the ordinary Madreporaria, as factors in reef-construction.

The first species of the hard-coralled Alcyonaria that invites attention is the well-known Music- or Organ-pipe coral, *Tubipora musica,* so called from a fancied resemblance in the arrangement of the associated tubes of which its corallum is composed to the pipes of an organ. As a rule, the Organ-pipe coral does not occur in social colonies, the coralla being found, either separately or in small isolated patches, further inshore than the ordinary corals, and most frequently where an accumulation of a certain amount of muddy sediment takes place. An exceptionally rich patch of this highly-characteristic coral is shown in the foreground of Plate XVIII., reproduced from a photographic view taken on the north shore of Thursday Island. Both the corallum and the associated zooids of the Organ-pipe coral are, as shown in Chromo plate X., Figs. 6 to 8, conspicuously coloured. The entire corallum, including the polyp-tubes, and the interconnecting horizontal calcareous laminæ, that bind them together at more or less regular intervals, is a bright crimson-red, while the star-like polyps, with their delicately-fringed tentacles, vary in colour from light emerald to a pale sage-green, or sometimes brown. The author was fortunate enough to secure a highly-characteristic photograph of a corallum of this species with a large number of its polyps fully extended. This photograph is reproduced as taken, to the natural size, in Plate XXVI. The species, while commonest in the hotter waters of Torres Strait, is to be obtained throughout the Barrier district.

The second coral-constructing Alcyonoid type met with on the Barrier Reef bears the popular title of the Blue coral, but is known to biologists under the technical name of *Heliopora cœrulea.* The coralla of this species takes the form of erect clumps, a foot or eighteen inches high, composed of more or less compressed, irregularly lobate, or digitiform, ramifications, which coalesce more or less extensively with one another. The superficial colour of the living corallum in this type is usually a dull bluish-grey ; but the interior, when broken through, is a bright indigo-blue that permanently retains its hue, whence the popular title has been derived. The species is an essentially tropical type, being most abundantly represented in the hotter waters of Torres Strait.

Until within a comparatively recent date, considerable uncertainty prevailed concerning the true zoological affinities of Heliopora. The balance of evidence, submitted chiefly by the American authorities, Agassiz and Dana, was in support of its close relationship to the Hydroid coral-building type Millepora, hereafter described ; and it was left to the late Professor H. N. Moseley, in connection with the scientific exploration cruise of H.M.S. *Challenger,* to demonstrate its rightful position among the Alcyonaria. As a matter of fact, this Blue coral is a very difficult form to study, it being so shy of expanding its polyps under artificial conditions, in

captivity, that few biologists have had an opportunity of observing it. Some phenomena of interest were associated with the author's earlier endeavours to make himself acquainted with the aspect and the structure of its living elements. The species was first obtained by him in the year 1889, in the neighbourhood of Warrior Island, Torres Strait; but, although placed in constantly renewed sea-water, and carefully observed night and day, the polyps refused to expand. In June of the subsequent year, 1890, the same species was obtained from the Mid-Brother reef in the neighbourhood of Adolphus Island, at the entrance to the same Strait, special facilities for visiting the district having been then accorded the author by Captain Dawson and the officers of H.M.S. *Rambler*, at that time engaged in making a new survey of the scene of the disastrous *Quetta* wreck.

Specimens of Heliopora obtained on this occasion were kept alive for some days on board the *Rambler*, and were ultimately brought on to Thursday Island in the living state, and deposited in one of the coral-pools at Vivien Point, utilised by the author for the cultivation of mother-of-pearl shell. During its retention on board-ship, the phenomena here recorded were observed, and accepted as furnishing a new clue to the affinities of this coral. The author not being cognizant at the time of the results of Prof. Moseley's investigations, and having Mr. Dana's work indicating its Hydroid relationship alone to refer to, the organism was approached with the anticipation of encountering a much modified Hydroid polyp, nearly akin, perhaps, to Millepora. How far the anticipation was realised will be shown. The surface of the corallum of Heliopora, it should be explained in the first place, is perforated with cylindrical pores of two dimensions, larger and fewer ones, which have a diameter of less than a millimetre, and, interspersed among these, innumerable smaller pores about one-fourth of the diameter of the larger ones. Within a few hours after bringing specimens from the reef and placing suitable fragments in sea-water, the presence of living organisms was made apparent, in the form of two slender transparent tentacles, which were seen protruding from each of the smaller pores, followed by a short portion of a cylindrical semi-transparent body. The aid of a pocket-lens was necessary to make out these details distinctly. At first sight, it was suspected that the organisms observed were allied to the bitentaculate Hydroid zoophyte, described many years since by Mr. P. H. Gosse under the title of *Lar sabellarum;* which inference, had it proved correct, would have given substantial support to the theory of the relationship between Heliopora and Millepora, and other coral-building Hydroids.

On the author's following up the superficial examination of the corallum, by making sections through its substance, and thus laying open the pores from which the tentacles protruded, a totally unexpected result was arrived at. It was then shown that the protruding tentacles were the terminal appendages of a long slender, setiferous, worm, subsequently ascertained to belong to the same family as, and to be very closely allied to, *Leucodore ciliata*, a species that has of late years been accredited with compassing the destruction of the New South Wales oyster-

beds. Hundreds of these worms were exposed to view in a section of the coral less than one inch square; they either remained contracted within their respective tubules or, wriggling out, fell through the water to the bottom of the glass dish in which they were under examination. The investigation was continued, with the object of ascertaining whether any distinct organisms were associated with the larger pores. These pores, however, appeared to be hermetically closed—with but one or two exceptions, and in these, worms similar in aspect to, but larger than, those inhabiting the smaller pores were seen protruding from their orifices. It appeared reasonable, under these circumstances, to think that the larger pores probably represented the brood chambers of the adult zooids, and that the entire corallum was built up by the worms that had been placed so conspicuously in evidence. The facts revealed by this investigation of Heliopora, which were fully demonstrated by the author at the time to the satisfaction of Dr. W. G. K. Barnes, R.N., and other officers of H.M.S. *Rambler*, appeared to differ so essentially from all previously recorded theories concerning the structure and affinities of the type, that a brief account was forwarded to *Nature*.

Meanwhile, a specimen of the Heliopora was conveyed to Thursday Island, placed in a coral pool easy of access, and examined from time to time, for the detection of any new developments. Until the end of five weeks from the day that the specimen was first collected no alteration, was noticed in the external aspect of the coral; the worms continued to manifest the same active vitality, protruding and extending their tentacles on all sides from the smaller pores, in search of food. The day before leaving Thursday Island a last visit was paid to the coral pool, when, to the author's astonishment, zooids, each with eight pinnate tentacles, were seen projecting from the larger pores. The fact was not immediately realised that these protruding zooids were Alcyonoid polyps. There are also pinnately tentacled annelids or worms, which in such instances as Filograna build up compound calcareous coral-like habitations; and this supported the conjecture that the larger zooids probably represented matured individuals of the undoubted worms which inhabited the more numerous smaller pores. A rough outline drawing of the protruding zooids as visible at the bottom of the pool was made on the spot; but, on the specimen being brought to the surface of the water for more careful examination, the animals slowly retreated into their respective cells, and they were seen no more in the living state, the specimen being subsequently transferred to spirit.

Later investigations showed that Professor Moseley's interpretation of the Alcyonarian nature of Heliopora was perfectly correct, with relation to the occupants of the larger pores and the construction of the greater mass of the corallum, and that that investigator had observed the worm which inhabits the exceedingly numerous smaller pores. To what extent these annelids contribute to the formation of the corallum of *Heliopora cœrulea*, or to the moulding of its characteristic minuter porous structure, remains to be discovered.

As so far investigated, the coral is shown to represent in its normal condition a most interesting example of what is known as "commensalism," or the sharing of a common domicile by two entirely distinct organisms. Illustrations of the corallum of *Heliopora cœrulea* with its zooids and commensal worms will be found on Plate X., Figs. 1 to 5, of the chromo-lithographic series. The entire coral, growing *in situ*, forms a conspicuous object in the foreground of the photographic view of a portion of one of the Madge reefs, Thursday Island, reproduced in the photo-mezzotype Plate No. XIX. In this reef-scape, the single conspicuous corallum of Heliopora occupies an isolated position among an otherwise unbroken expanse of the more normal leathery Alcyonarian polyparies. On other reefs, in the vicinity of Thursday Island, this interesting type has been observed by the author growing more abundantly, though not to the extent asserted by Jukes in his narrative of the voyage of H.M.S. *Fly*, who says that it represents the most plentiful coral genus on the reefs of Bramble Cay, a small rock and coral islet situated in the extreme north-east of the Torres Strait limit of the Great Barrier system.

Attention may now be directed to some few of the many flexible or leathery-coralled Alcyonaria (typical Alcyonidæ) that enter conspicuously into the composition of the tidally-exposed reefs of the Barrier system. As previously remarked, these flexible Alcyonaria rapidly disintegrate on death, and can contribute little, beyond the drifted accumulation of their component calcareous spicules, to the building up of the permanent reef rocks. Moreover, as these spicules, are of microscopic minuteness, it is an open question whether they are not dissolved by certain products of decomposition of the organic tissues, in relation to which they were originally secreted. While thus disappearing with the suspension of vitality, they play a very important part, in their living condition, in the function of reef-construction. A reference to the photographic views reproduced in Plates XX.A and XX.B, in addition to that of Heliopora, No. XIX., last named, will suffice to substantiate this assertion. In each of these illustrations, it will be seen that members of the group monopolise the greater part, if not the entire surface, of the reef-scape. As thus viewed, in their high and dry condition, with all their polyps completely retracted, the coralla of these leathery corals present a general appearance which resembles that of many fungi. After the manner of those cryptogamic plants, they have a tendency to spread themselves insidiously over all neighbouring objects, represented in their case by the reef rocks and more solid Madrepores. The contours and colours of these tidally-exposed Alcyonaria vary among the different species, and also among individual growths of the same species. The commonest form, *Sarcophyton glaucum*, represented in the left-hand foreground of Plate XIX., has a corallum which, in its earliest growth phase, is sub-orbicular in shape and attached by a thick fleshy stalk, after the manner of an ordinary mushroom. As it increases in age, the stem remains relatively short, while the circumference of the disk becomes irregularly lobed and convoluted, and so increases in diameter that the adjacent coralla overlap one another, as illustrated in the plates referred to. The colour of the coralla of this species varies, most commonly from a

light-liver to a bright golden-brown; exceptionally it is a light stone-yellow, greenish-brown, bright-bronze- or verdigris-green. It has been observed of this type, by the author, that the individual coralla are capable of changing their characteristic superficial colour within a short interval of time. A specimen kept in a basin of constantly-changed sea-water was, when originally collected, of a bright verdigris-green hue; a day later it had assumed a commoner and more sombre olive-brown; but a few days subsequently it reverted to its original verdigris tint. It would appear, from the phenomenon now recorded, that the collective polyp stock exerts some specific control over the superficial pigment corpuscles of the common corallum.

The colour and aspect of the associated polyps of *Sarcophyton glaucum* present little variation. In their condition of full extension, these polyps stand out from the fleshy disk on slender stalks, that vary from half-an-inch to nearly an inch in length. The eight-rayed tentacular star that surmounts each slender stalk is almost invariably bright lemon-yellow; while the supporting stalk itself, most commonly dark liver-brown, may be a lighter shade of the same tint. The extended polyps of this Alcyonarian are extremely minute, not exceeding one quarter of an inch in diameter; and, being crowded together in close proximity, countless myriads are included in a single corallum of the ordinary size. Such is the close order in which these polyps are associated, that no part of the corallum is visible when they are all fully extended. Representations of the living coralla of this species, together with the polyps in various stages of extension, are included in Figs. 18 to 20 of Chromo plate No. X. As there shown, the tentacular lobes are not fringed after the manner of those of the majority of Alcyonarian polyps.

In a second form, identified with the *Alcyonium latum* of Dana, but probably referable to the genus Sarcophyton, the corallum is represented by fleshy folia, deeply indented on one side and radiating from a common centre. Its colour is liver- or golden-brown, and the extended polyps are bright lemon-yellow with brown stalks, as in the type last described. A typical illustration of this species is presented in the foreground of the upper reef-view in Plate No. XX. A third type, identified by the author with the *Alcyonium murale* of Dana, builds up a corallum resembling a corrugated sheet of light liver-coloured leather, that may cover an area of many yards. A single extensive colony-stock of this variety, as illustrated by the lower reef-scape in Plate XX., may, in point of fact, occupy the greater portion of the field of view. The polyps of this species, also, as in the preceding types, are primrose-yellow with brown stalks. A large portion of the reef-scape of Plate XIX. is occupied by a species, apparently identical with the *Alcyonium flexile* of Dana, in which the edges are developed into attenuate digitiform prolongations. Both the polyps and the supporting stalks in this species are primrose-yellow.

It is characteristic of the species of the two genera Alcyonium and Sarcophyton, just described, that the polyps in their retracted state are withdrawn entirely within the substance of their polyparies. In another section of the Alcyonarian order, the polyps, when

contracted, do not completely disappear within the substance of the corallum, but remain on its surface in the form of minute spherular aggregations, which, in association with the abundant spicular encrustment, communicate to the corallum a rough granular, in place of a smooth leathery, texture. The colony-stocks in this group, represented by the genus Spongodes and its allies, usually consist of fleshy incrustations, out of which arise independent coralla, mostly of a subclavate outline, with their distal extremities subdivided into short, ramifying branchlets. Among the numerous species of this series that are conspicuously represented on the tidally-exposed coral-reefs of the Great Barrier system, the form growing in masses to the extreme left in the foreground of the reef-view, Plate III., probably occupies the most prominent position. The same species is less conspicuously represented, on either side of the radiating leathery type, *Sarcophyton radiata*, illustrated in Plate XX. The ordinary colours of the coralla of this species of Spongodes are a pinkish-lilac, inclining sometimes to a bluish and in others to a reddish shade of the same tint ; while the spherular polyp aggregations, usually a lighter hue of the general ground colour, are not unfrequently bright golden-yellow. In contrast with those of the leathery types, previously enumerated, the polyps in this genus are not, in extension, mounted on elongated stalks, but attached in an almost sessile manner to the lobate branchlets of the corallum. Typical coloured illustrations of the corallum and polyps of this genus are included in Figs. 11 and 12 of Chromo plate No. X. In a second species of the genus Spongodes, which not unfrequently forms considerable patches on the reefs in Torres Strait, the entire corallum with the associated polyps is an opaque creamy-white.

The genus Xenia and its allies, represent a third group of the Alcyonarian corals that enters largely into the reef fauna of the Great Barrier system. Its members may be distinguished from those of the preceding genera, by the fact that the component polyps are entirely incapable of contraction, and merely fall together into a shapeless mass on the retreat of the tide. Many species of this genus, in addition to forming extensive patches on the surface of the reef, hang in dripping clusters, when the tide is down, from the under sides of hollow rocks or coral boulders. The polyps of all the observed members of the genus Xenia are considerably larger than those of the preceding genera, their expanded tentacles not unfrequently measuring as much as, or more than, an inch in diameter. These polyps, moreover, exhibit a far more extensive range of coloration, the tints in many instances being remarkable for their delicacy. The general aspect of an individual polypary of this Alcyonarian genus may be aptly compared to a sheaf, having a subcylindrical consolidated base, with delicate, eight-petalled, star-shaped flowers radiating in profusion from its summit. Among the more notable Barrier Reef representatives of these sheaf-like forms, one species, identified by the author with the *Xenia elongata* of Dana, has polyps about half-an-inch in diameter, whose tentacles are the most delicate porcelain- or electric-blue, their individual stalks and the common supporting base being a somewhat browner shade of the same tint. This specific type is a representative of the series in which the tentacles, instead

A. OUTER BARRIER REEF, WITH GIANT CLAMS AND BÊCHE-DE-MER.

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

B. OUTER BARRIER REEF, WITH EMPTY SHELL OF GIANT CLAM.

of being distinctly fringed or pinnate, have their upper surfaces minutely warted. Its polyparies often form patches several yards in extent on the surface of the reefs; one such patch is included, although showing somewhat indistinctly, in the background towards the left of the photographic reef-scape reproduced in Plate XIV. A coloured representative of a fully-expanded polypary and of an enlarged polyp of this species, is delineated in Figs. 13 and 13A of Chromo plate No. X. It is desirable to mention here that a decidedly lilac tint has been accidentally substituted by the lithographic artist, for the typical pale porcelain-blue tint that distinguishes the living organism. In another species of the warted-tentacled Xeniæ, the polyps and the common supporting stalk are a light stone-colour, and the minute tentacular warts and the oral disk opaque white. This species, which is provisionally associated with the title of *Xenia ochracea*, is represented by Figs. 14 and 14A of the chromo plate last mentioned.

A second group of the sheaf-shaped Alcyonaria, hitherto included in the genus Xenia, contains those varieties in which the tentacles are distinctly pinnate. Among this series, one interesting variety, obtained by the author at Warrior Island, Torres Strait, is remarkable, not only for the size and delicate coloration of its polyps, but also for certain special physiological manifestations. The expanded tentacles in this type measure over an inch in diameter. The colour of the stalks and of the main shafts of the tentacles is a pale beryl-green, while the conspicuous tentacular pinnæ, and the substance of the common supporting polypary, are a pale ochreous-brown. The special physiological phenomenon observed of this type was associated with the movements of its tentacles. In all ordinary polyps, whether belonging to the coral-secreting or skeletonless sections, the component tentacles move quite independently of one another, and their action is either irregularly vermiculate, or one of simple extension and retraction. In the present type, on the contrary, all of the eight tentacles move synchronously, opening out and contracting in a continuous measured rhythm, averaging two seconds to each contraction. The action thus observed was in all respects identical with the pulsating contractions of a jelly-fish, and was suggestive of a less remote affinity between the Alcyonarian tribe and the medusiform Hydrozoa than subsists between the last-named tribe and the coral-forming Madreporaria or skeletonless Actinozoa. This suggestion of affinity receives substantial support from the fact that as the radial processes throughout the jelly-fish tribe are invariably a multiple of four, and most commonly eight, they thus correspond in number with the tentacular organs of an Alcyonarian, while among the typical existing Madreporaria and Actinaria they are as invariably a multiple of six. In fact, were the outspread tentacles of a polyp of the pulsating Xenia, here described, united by a transparent membrane, a jelly-fish or medusa-like organism would result, so far as the general external features would be concerned. It not having been found possible to identify this interesting type with any previously-described species, it is herewith associated with the appropriate title of *Xenia pulsitans*. Its polyparies, as shown in the coloured illustration, Fig. 16 of Chromo plate X., embrace only a small number of associated polyps.

A second species of the fringe-tentacled Xeniæ, which is abundantly represented on the Barrier reefs, very much resembles in its external aspect the variety *Xenia ochracea*, described in a previous paragraph. The polypary is commonly a pale pinkish stone-colour, and the distinctly-fringed polyp-tentacles are a decided brown. No pulsating motion, as in the type last described, is exhibited by this species. The aggregated polyparies of this form not unfrequently cover very extensive areas on the reefs; and when, as commonly happens, they grow under such conditions that they are left, on the retreat of the tide, in natural pools, with only a few inches of water over them, their expanded sheaf-shaped coralla and extended polyp-stars present a remarkably pleasing spectacle. An illustration of an expanded polypary of this species, together with a magnified polyp, is included in Figs. 15 and 15A of Chromo plate X., and, in the absence of discoverable evidence of its previous description, it is herein associated with the title of *Xenia brunnea*. Concerning the genus Xenia, collectively, it is undoubtedly desirable, for purposes of systematic classification, that the two distinct natural series represented by the fringed-tentacled and warted or tuberculate-tentacled species should be generically separated. As the fringed-tentacled series, typified by the Red Sea, *Xenia umbellata*, of Savigny and Lamarck, possesses the more valid claim to the original generic title, a new one, that of Paraxenia, is herewith proposed, for the reception of those forms, such as *Xenia elongata* and *X. ochracea*, previously described, in which tentacle-pinnules are represented by minute wart-like prominences, which probably perform an adherent or suctorial function.

A small group of the Alcyonaria remains to be noticed, in which the polyps, in place of being bound together in such a manner as to form a more or less compact corallum, are simply held in union with one another through the medium of a common creeping root, or stolon, out of the substance of which new polyp-buds are continuously developed. These proliferous roots, or stolons, may so ramify or interlace with each other as to form a thickly-matted polypary, under which conditions the expanded polyps appear, from a surface view, to arise as in the preceding species from a common, compact base. This structural modification is appositely illustrated by a type, *Clavularia viridis*, that is very abundant on the reefs, in the vicinity of Thursday Island and throughout Torres Strait. The species, delineated in Fig. 17 of Chromo plate No. X., is an exceedingly handsome one; and the individual polyps, for an Alcyonarian, are of considerable size. The expanded tentacular crown measures as much as an inch to an inch and a half in diameter, and is mounted on the summit of a subcylindrical or clavate stalk, which springs perpendicularly from the prostrate stolon. The component tentacles in this type are remarkable for the length and luxuriant development of their secondary branchlets, or pinnules. These slender filamentous pinnules are very frequently of a bright golden-green colour; and, where the polyps are thickly massed together, they so completely conceal all other structural details from view, that the colony-stocks present the appearance of waving tufts of living moss. The creeping stolon, the erect stalk or column, and the central shafts of the tentacles of this species, are usually a light

reddish or purple-brown. The conspicuous local colour variations of the tentacular filaments of this handsome species have been observed to vary from light brown through golden-yellow to emerald-green, their extreme tips in some instances being lemon-yellow. On being left dry by the tide, the polyps of this Clavularia close like those of ordinary sea-anemones, the tentacular wreath being completely retracted. Several clusters or colony-stocks of this species in their high and dry, and consequently retracted, condition, are included in the photographic reef-view reproduced in Plate XIX., occupying therein a position to the right-hand side in the immediate foreground.

Two smaller members of the stoloniferous section of the Alcyonaria, referable apparently to the genus Cornularia, are represented in Plate X. of the chromo-lithographic series. In the first of these, Fig. 22, the expanded tentacular crown is not more than a quarter of an inch in diameter, and is coloured, with the exception of the light brown stolon stalk bases, oral centre, and crenated edges of the tentacles, a pale sage- or beryl-green. In an exceedingly minute species closely allied to the form just described, and represented by Fig. 21 on the same plate, the tentacular crowns were entirely dark golden- or metallic-green, suggestive in miniature, when seen in profile, of the characteristic pedicellated crest-feathers of the peacock. With reference to this fanciful resemblance, it is proposed to associate this minute form with the title of *Cornularia pavo*, distinguishing the preceding, slightly larger, type by that of *Cornularia glauca*. A third species of the same genus, found growing in tufts on a muddy foreshore at Thursday Island, was, in the first instance, taken for a small species of Organ-pipe coral, Tubipora. The apparent reddish calcareous tubuli proved, however, on nearer examination, to be of corneous consistence, and united to one another, inferiorly, by a reticulated stolon. The distinctly developed tentacular fringe in this species was light brown, and the main shafts of the tentacles, and also the peristomial disk, were yellowish-white. Representations of an expanded colony-stock, and of an isolated polyp, of this type, here associated with the title of *Cornularia tubiporoides*, are included in Figs. 9 and 10 of Chromo plate No. X.

A very elegant little Alcyonarian, that differs somewhat from the several previously enumerated species of Cornularia, in that its tentacles are smooth and devoid of either tubercles or pinnules, is delineated in Fig. 8 of Chromo plate No. III. The peristomial disk in this type is a pale apple-green, the eight radiating tentacles are dark chocolate, and the supporting stalks and interconnecting stolon are of a light brown hue. All efforts to identify this form with some previously described species having proved unsuccessful, it may be appropriately associated with the name of *Cornularia auricula*.

That group of the Alcyonaria entitled the Gorgoniaceæ, which includes the "sea-ferns" and other allied arborescent coral-growths, whose polyps correspond structurally with those of the Alcyonaria previously enumerated, is very rarely represented on the tidally-exposed reefs of the Great Barrier system, almost all its members being inhabitants of deep water. A

species of Gorgonia collected on the Palm Island reefs, apparently identical with the *Plexaura salicornoides* of Milne Edwards, is, as a matter of fact, the only type the author found growing, in a position accessible by wading, throughout the reefs explored. The dead coralla of several forms of more than ordinary interest are, at the same time, washed up in some quantity on the coral beaches, and consequently contribute a small quota towards the solid reef-formation. Other conspicuous forms are not unfrequently brought in by the pearl-shell divers, from the fishing grounds in Torres Strait. These arborescent Alcyonaria exhibit several distinct growth-formations. In the group represented by the typical genus Gorgonia, the corallum takes the form of a tree- or bush-like structure having a central, more or less flexible, horny axis, which is enclosed within a bark-like cortex. This external cortex, which is alone visible in the living corallum, represents the associated polyps with an intervening matrix bearing aggregated spicules, analogous to that which alone builds up the leathery polypary of the typical Alcyonidæ. The surface of this outer cortex is found, on near examination, to be thickly perforated with minute holes; from each of these, in the living corallum, an eight- pinnately-tentacled polyp expands or contracts at will, as obtains among the simpler leathery Alcyonidæ above referred to. A characteristic illustration of this particular group is furnished by *Ctenocella pectinata*, represented by Plate XI., Fig. 3, of the chromo-lithographic series, in which the coralla present a peculiar comb-like form, all the secondary branches being developed in the same plane and on the same side of the main rachis. The colour of the outer, spiculiferous, cortex in this species exhibits a wide range of variation, being in some examples a bright brick-red and in others creamy-white, while every gradation of tint between the two may be met with. The expanded polyps, as is the case with almost all members of the Gorgoniaceæ, are colourless, and nearly transparent. A nearly allied, more normal, representative of the same group, *Gorgonia australiensis*, also commonly obtained by the pearl-shell divers in Torres Strait, is delineated by Fig. 4 of the chromo plate above referred to.

Among the species that are not uncommonly washed up on the coral beaches of certain of the Capricorn group of islands, one form, *Isis hippuris*, is remarkable for the fact that its corallum is built up of two distinct elements, that are distributed in alternate joints of variable lengths. The more massive of these is white and chiefly calcareous, being composed of consolidated spicules; while the other is black, and composed almost exclusively of the dense horny material that constitutes the entire axial corallum in the typical Gorgonidæ. The cortex and polyps in this singular jointed coral are indistinguishable from those of the species last described. An illustration of this interesting type is given in Figs. 1, 1A, 1B of Chromo plate No. XI. Another noteworthy species of the Gorgoniaceous tribe is represented by *Melitodes ochracea*, a robust arborescent type, whose erect, branching corallum may attain a height of two or three feet, and its main trunk a thickness of three or four inches. The corallum or "sclerobase" in this instance more nearly resembles the calcareous internodes

of *Isis hippuris*, consisting throughout of densely aggregated calcareous spicules. The colour of this corallum is more usually a bright brick-red on the surface, shading off to ochreous yellow, or a lighter tint of red, internally. The cortical substance is very sparsely represented in this type, and consists only of loosely aggregated spicules, which fall apart almost immediately after the death of the associated polyps.

Melitodes ochracea is of more than ordinary interest, since it represents an intermediate type between the ordinary flexible Gorgoniaceæ and the precious coral of commerce, *Corallium rubrum*. In the last-named species, the central solid corallum is originally constructed of loosely aggregated spicules, which become so closely amalgamated that its texture assumes the density of marble, and is capable, like that substance, of taking the highest polish. The corallum of Melitodes, while apparently solid to superficial vision, is found, on near examination, to be minutely porous, and is, in consequence, incapable of taking a polish. Although no variety of the red coral of commerce has as yet been obtained from Australian waters, the conditions would appear to be favourable to its growth throughout a large area of the Queensland coast-line; and, if not indigenous, it might, under suitable auspices, be artificially introduced and made the subject of a new and highly profitable industry.

CLASS HYDROZOA.

The polyps belonging to the Hydrozooid subdivision of the Cœlenterata are distinguished by the possession of a much simpler structural organisation than that of either the Actiniæ, Alcyonaria, or coral-producing Madreporaria. The most essential character that distinguishes the polyps of the Hydrozoa, from those belonging to any of the orders above enumerated, is associated with the fact that the body of the Hydroid polyp encloses a single central cavity, while in all Actinozoa the cavity in question gives rise to a series of outgrowths, which more or less completely surround it, and whose walls give rise to its contained mesenteries, or sarcosepta. The Hydroozoon body may be compared to a sac, with its mouth so inverted, or doubled back within itself, that in diagrammatic transverse section it would be represented by a double tube, the outer one corresponding with the body-wall of the polyp, and the inner one with its alimentary tract.

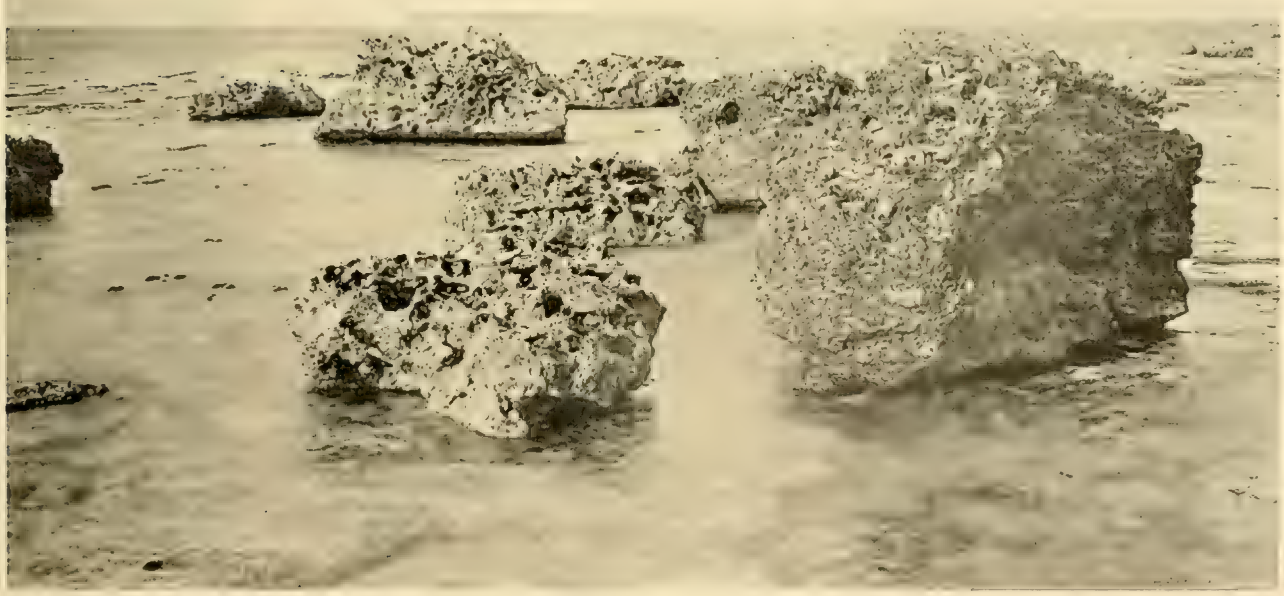
The greater number of the animals referable to the class Hydrozoa are included in the ranks of the ordinary jelly-fishes, or Medusæ, and in that extensive group of attached, seaweed-like, organisms popularly entitled Sea-firs or Hydroid Zoophytes. There are a few, more exceptional, types belonging to this class, that secrete solid coral-like structures, which, being represented in the Great Barrier fauna, have to be taken into account in this volume. The only generic type, in point of fact, that may be said to contribute to any material extent towards reef-construction in the Barrier system, is that of Millepora. As many as three species of this genus have been

collected by the author in the Barrier area; and two of them form such substantial coralla as to represent a conspicuous feature in the coral landscape. In one of these species, *Millepora alcicornis*, the corallum takes the form of a thick bush-like aggregation of flattened palmate, or frondose, expansions, all of which are disposed in the same vertical plane. This species is very characteristically represented in the photographic reef-view reproduced in Plate VII., wherein it occupies a prominent position, in mid-distance towards the right-hand side. The second species of the genus, *Millepora ramosa*, forms cylindrical, dichotomously branching, shrub-like coralla, much resembling those of many ordinary Stags'-horn corals of the genus Madrepora. This species, which is rarely uncovered at ebb-tide, is very abundantly represented in Plate X., No. 1, illustrative of a portion of the fringing reef off one of the Palm Islands, in which the coral may be recognised, forming thick bush-like clumps immediately beneath the surface of the water. Some few additional species of the genus Millepora have been obtained from the Barrier district; none of them, however, appear to construct coralla of substantial size, and they for the most part form simply nodular or encrusting masses.

The coralla of the Millepores may be readily distinguished from those of the typical Madrepores by the character of the "polyp cells." Instead of taking the form of definite corallites subdivided by symmetrically radiating septa, these "cells" are represented by simple circular perforations, most commonly forming distinct groups, in which one slightly larger perforation occupies a central position, and has distributed around it, at uneven distances, some four or five smaller pores. The true nature and affinities of the Milleporidæ were first pointed out, many years since, by the American naturalist, Alexander Agassiz; but it remained for Professor H. N. Moseley, in association with the scientific expedition of H.M.S. *Challenger*, to elucidate thoroughly the full details of their structure; and upon his important monograph on the subject the illustration of the polyps of *Millepora alcicornis*, given in Chromo plate VI., Figs. 8B and C, have been based. A small portion of the corallum is also shown in its natural size and colour in Fig. 8 of the same plate. As with the anomalous Alcyonoid coral, *Heliopora cœrulea*, described on a previous page, the polyps of Millepora appear to be exceedingly shy of expanding when in captivity. During none of the short intervals in which living coralla of Millepora were under the author's observation, was the much-looked-for expansion of the polyps observed.

There is another genus of the class Hydrozoa, in addition to Millepora, which secretes a dense calcareous corallum, and contributes its share, in death if not in life, towards the building up of the Great Barrier edifice. This is the *Distichopora coccinea*, represented by Figs. 6 and 6A of Plate XI. of the coloured series. The most conspicuous feature of this type is its brilliant vermilion red or crimson hue, combined with a not inconsiderable superficial resemblance to the precious coral of commerce, *Corallium rubrum*. On nearer examination, however, it is found to differ so fundamentally in its minute structure, that it is valueless for commercial purposes. In addition to the larger perforations, resembling those of its near

A. FLOTSAM.—WRECK OF NEW GUINEA MISSION SCHOONER "HARRIER."



W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

B. JETSAM.—STORM-STRANDED CORAL ROCKS, CAPRICORN ISLANDS REEF.

ally, Millepora, which are disposed in regular series, as shown in Fig. 6A, along each, opposite, narrower border of the conspicuously compressed corallum, its substance is finely porous throughout, and hence incapable of taking a high polish. This Distichopora is never found growing on the reefs, but is not uncommonly washed up from deep water, on the beaches of the coral islets, throughout the Barrier district. An allied but more slender growing type, *Allopora sanguinea*, of a delicate rose-pink colour, with subcylindrical branches, that subtend on the same uniform plane, is usually accredited with an Australian, Barrier district, habitat. The author has diligently searched and enquired for evidence of its existence in Australian waters without success; its headquarters lie undoubtedly farther eastward, among the reefs and atolls of Polynesia.

The flexible seaweed-like Hydroid zoophytes, that contribute so extensively to the fauna of the littoral zone in almost all temperate regions, are very scantily represented in the coral-producing tropical waters. There is one genus, however, *Aglaophenia (? Macgillivrayi)*, that occurs in some abundance in the pools, among the reefs abreast of Cape Flattery, familiar to the Bêche-de-mer fishers on account of its stinging properties. When handled, or incautiously trodden on with bare feet while wading, the sting produced by contact with its polyparies much resembles that caused by an ordinary stinging nettle, or the stinging anemone, *Actinodendron alcyonoideum*, described on a previous page. The rash raised, as tested by the writer, remains conspicuously visible, and is accompanied by gradually decreasing local irritation, for about a week.

That comprehensive section of the Hydrozoa which includes the innumerable varieties of Medusæ or jelly-fishes, is very abundantly represented in the waters that lave the Great Barrier reefs. Among the generic types represented in this connection, mention may be made of Physalia, Velella, Porpita, and also the Ctenophor, *Cestus Veneris*. Many of the jelly-fishes, more notably the so-called Portuguese man-of-war, *Physalia pelagica*, are conspicuous for their severe stinging properties. There is one species, however, that has been reported to the author as not unfrequently appearing in Cleveland Bay, off Townsville, whose urticating properties are so severe that death has been known to result to bathers from contact with its trailing tentacles. The efforts that have been made to obtain either specimens of this noxious Hydrozoon or sufficient data for its approximate specific identification, have so far proved unsuccessful. It would appear, however, from the scant evidence gathered, to be a representative of the Physophorous Medusæ, rather than a form allied to Physalia. It is worthy of note that a large proportion of the free-swimming Medusæ represent the sexually specialised derivatives of sedentary compound Hydroids, from whose polyparies they become detached as minute transparent bells, which may rapidly grow to relatively gigantic dimensions. The possibility naturally suggests itself that the death-dealing Medusa of Cleveland Bay is the derivative of the sedentary, urticating *Aglaophenia*, referred to in the preceding paragraph.

CHAPTER V.

PEARL AND PEARL-SHELL FISHERIES.

The pearl and pearl-shell fisheries of Queensland occupy a prominent position among the most important commercial industries of that colony. An approximate estimate of their worth may be gained by a reference to the following table, extracted from the official statistics, such extract indicating the relative values of the ten leading Queensland exports for the five years 1884 to 1888.—

STATISTICAL TABLE SHOWING THE VALUE OF THE TEN LEADING QUEENSLAND EXPORTS.

Articles Exported.	1884.	1885.	1886.	1887.	1888.
	£	£	£	£	£
1. Wool	1,889,504	1,779,855	1,413,908	2,368,711	2,258,365
2. Gold	923,010	1,119,170	1,232,330	1,432,376	1,662,639
3. Sugar	454,995	720,921	855,510	758,215	384,375
4. Tin	228,457	156,777	192,564	223,274	230,360
5. Hides	109,291	125,603	101,870	101,086	30,217
6. Pearl-shell*	94,152	88,210	68,596	49,780	50,332
7. Live Stock	78,400	4,461	43,113	37,295	3,089
8. Preserved Meats...	57,274	171,638	2,303	105,340	79,187
9. Tallow	76,031	97,706	33,434	99,094	75,193
10. Silver Ore	24,756	20,601	22,127	22,422	7,297

* Tortoise-shell, having an annual export value of from £400 to £500 only, is included with the sum representing Pearl-shell in the original statistical table quoted.

The foregoing statistical table shows that pearl-shell has occupied a position fluctuating between that of the sixth and the eighth on the list of the most important exports, for the period quoted; its average annual value for the last five years being £69,000. Concerning the other fisheries of the colony, the two next most important, those of the ordinary oyster and Bêche-de-mer, produce annually a total value representing collectively little less than half of that realised by the pearl-shell fishery, the average export value for the five successive years

assigned to two fisheries combined, being only £30,000. The importance of the pearl-shell fishery, as representing one of the most valuable natural sources of wealth to the colony, is made evident, in the foregoing statistical table; and it is almost needless to suggest that so important an industry demands every attention and encouragement, in the direction of judicious conservation, and scientific development.

The pearl and pearl-shelling industry of Queensland is confined to the tropical area of the Queensland coast-line, or, in other words, is essentially associated with the Great Barrier district.

Its headquarters are at Thursday Island, Torres Strait, 10½ degrees S. lat., 140 degrees E. long., and thirty miles north-west of Cape York, the northernmost point of the Australian continent. All the licenses for vessels, boats, and men employed in this fishery, are taken out at Port Kennedy in Thursday Island; and from this centre, shelling expeditions are made along the mainland coast-line to the northern limits of the Great Barrier coral-reef, and throughout Torres Strait northward to the vicinity of New Guinea. Within recent years pearl-shell has also been obtained in some quantity on the east shore of Cape York peninsular, in the gulf of Carpentaria. As a result of his official investigation of that district in the year 1891, the author was able to report its presence also in the neighbourhood of Sweer's Island, one of the Wellesley group, farther east in the same gulf.

The average depth of water from which the greater quantity of the mother-of-pearl shell is at present collected is seven or eight fathoms. In former years it was abundant, and it is even now occasionally obtained in water of such little depth, that it can be gathered with the hand at low spring-tides. Twenty fathoms represent about the greatest depth from which the shell is profitably fished, although few divers can stand the strain of prolonged work under that pressure. Some of the largest shell now placed on the market is collected at the above-named depth from off the New Guinea coast.

The following data concerning the licensing fees and the general conditions under which the pearl-shelling industry is prosecuted in Queensland-waters, may prove of interest, and also of some utility as a guide to immigrants to Queensland, who may elect to invest capital in this important and (where skilfully conducted) highly profitable industry. The annual licensing fee charged for every boat employed is 10s.; for every ship of ten tons burden or under, £3; and 10s. for every ton or part of a ton above ten tons. Divers or sailing masters pay a license of £1; and £5 per annum is charged for the right of occupying Crown lands, for the erection of stations and buildings connected with the industry. A small royalty is now levied on the amount of shell collected—assessment being made at the rate of £2 for every ton of shell exported.

The number of licenses for shelling craft granted at Thursday Island for the past few years is about 100. This is a slight increase on the figures for some preceding years, but a falling-off

compared with those of earlier ones. This diminution is to be accounted for chiefly by the considerable migration of Torres Strait vessels to the West Australian grounds that took place in the year 1886, from which field many of them have since returned. The number of hands engaged in the Torres Strait industry may be computed at 1,000, this including, besides the boats' crews, those occupied ashore in the management of the stations, in the repairing of boats and gear, and in the preparation and packing of the shell for export. Of the pearling vessels licensed from Thursday Island, it is worthy of remark that the greater number are owned by Sydney capitalists. It may be surmised that a much more considerable development of the industry by Queensland settlers will follow upon the granting of durable leases, in lieu of the commutable annual licenses for station areas, provided for through the recent Act of Parliament.

The vessels employed in the Queensland pearl-shell fishery consist chiefly of strong lugger-rigged craft, averaging ten tons burden, supplemented in some instances by cutters of larger size, which serve as purveyors to the luggers and to bring the shell collected into port. The crews manning these luggers comprise the diver, who takes command and acts as sailing master, one tender, who holds the life-lines and attends to all signals from the diver when at work, and four working hands, who, in pairs, take alternate shifts at the manual pumping apparatus for supplying air to the diver. With but few exceptions, the entire crews consist of coloured men of various nationalities. Mainland aboriginals, South Sea Islanders, and natives from the Torres Strait Islands furnish the greater number; while some of the best divers are represented by Manilla-men, Chinese, Japanese, and Malays. The few European divers are mostly the proprietors of their own boats. The shelling luggers are usually provisioned for one month, but may stay out longer, having the requisite stores brought to them by the cutters. The primary cost of a fully-equipped pearl-shelling lugger of (say) 10 tons, averages £650, out of which £150 may be set off as the price of the diving apparatus and pumping gear. The wages earned by the crews are as follows: The diver from £2 to as much as £4 10s. for 100 pairs of shell raised, £3 being a common average. The tender £3, and the four pumping hands £2 10s. each per month. Rations for the entire crew average about £9 monthly. The cost of maintenance, including wages and rations, but not the diver's earnings, which necessarily vary, may, therefore, be set down at an average of £22 for the month.

A fairly remunerative quantity of shell for a boat to bring in, as the result of one month's work, is from 600 to 700 pairs, which, consisting of, or reckoned as, 3-lb. shell, would represent but little short of a ton in weight. In fine weather, and under exceptionally favourable conditions, as many as from 1,200 to 1,800 pairs may be obtained; and it is the custom among certain of the station owners and boat proprietors to give the divers and crews a bonus for all shell collected numbering over 1,000 pairs. The agreement with the divers in reckoning up the number of shell brought in is usually to count it as 2-lb. or 3-lb. shell, such terms signifying that

all the pairs of shells as they are naturally attached must weigh not less than 2 lb. or 3 lb. each. Any pairs short of this weight have other shells added, until the standard weight is arrived at. In the case of very small shell, it may take three pairs, or six shells, to make up the 3 lb., or even seven pairs to complete 6 lb., or a standard two pairs, which are usually weighed in at once. £200 per annum, in addition to his rations, represents a fair average income for a diver.

The size, weight, and quality of the pearl-shell obtained from different localities varies materially, while, owing to the considerable depletion of certain of the most readily accessible fishing grounds, the average standard of size and weight is much lower than in former years. Large shell weighing 6, 7, or even 8 lb. the pair, representing from 300 to 400 pairs to the ton, is still to be got at Mangrove Island and Wappa, towards the New Guinea coast, and was formerly of common occurrence throughout the Strait. At the present time shell weighing 3 or 4 lb. per pair, or from 550 to 700 pairs to the ton, is regarded as fine shell, while the more ordinary yield averages from 800 to 1,200 pairs to the ton, representing from 2 to 2¾ lb. per pair. A very considerable quantity of shell was, until quite recently, brought in weighing from 1 lb. to as little as 5 or 6 oz. only per pair—that is, from 2,240 to over 6,000 pairs to the ton. As recognised by all of the more experienced and enlightened members of the trade, this wholesale destruction of the immature shell was very seriously impairing the productiveness of the fishery; and hence, at their own instigation, an Act of Parliament has been recently passed, prohibiting the taking of shell, with certain exceptions, having a less diameter than seven inches outside measurement, or six inches across the pearly lining or "nacre."

Regarding the quality and present value of Queensland pearl-shell, the following quotations have been supplied by the manager of one of the principal shelling stations:—

Very best shell ...	... £8	17	6	per cwt.	=	£177	10	per ton.
Good shell ...	... 6	15	0	,,	=	135	0	,,
Second quality ...	... 4	10	0	,,	=	90	0	,,
Poor	... 3	0	0	,,	=	60	0	,,

The average price now realised on the fishing grounds in Torres Strait is £125 per ton gross, or £100 net, while the common all-round price at which the shell is bought in by leading mercantile firms stationed at Thursday Island is £90 per ton. In former years the price for shell of good quality ranged as high as £200 per ton; the shell itself was more readily accessible and obtained at less cost, and the profits in the trade were consequently much more considerable. A little over twenty years ago, immediately before the discovery of the West Australian shelling grounds, prices as high as £16 and £20 per cwt., or from £320 to £400 per ton, were realised for the best Manilla shell. At the present time the best shell in the market is obtained from Torres Strait.

The specific form of pearl-shell yielded by Queensland waters and so far utilised for commercial purposes is the *Meleagrina margaritifera*, L., or typical mother-of-pearl, and pearl-producing

shell of the Indian and Pacific Oceans. Two prominent varieties, the one with a golden edge, and the other having a uniform silvery or nacreous consistence throughout, are pretty evenly intermingled, and do not, so far as the author's investigations have extended, present any marked distinctions in the aspect or structure of the contained animal. The last-named variety, having the nacreous lining, or true mother-of-pearl, pure and uniform throughout, is the more valuable, as it cuts up to greater advantage. This same large white mother-of-pearl shell, or "White Shell," as it is commercially designated, is occasionally on the Western Australian coast suffused with an exquisitely delicate pale pink hue, while in the neighbourhood of Manilla and the South Sea Islands the same species is frequently highly iridescent in association with a distinct golden sheen. For commercial purposes, these abnormal variations are held in little repute, the purest white shell invariably commanding the highest price. A smaller black-lipped shell, rarely exceeding a diameter of six or seven inches, with a weight of from 1 lb. to $1\frac{3}{4}$ lb. per pair, is common throughout the Barrier district, but has not hitherto been turned to much commercial utility in Queensland. This smaller species is, however, extensively fished for on the West Australian seaboard and in the Indian and China seas, both on account of the marketable value of the shell and the number and good quality of the pearls that it produces. In West Australia, the range of this smaller black-lipped species extends as far south as Champion Bay, or a latitude of 29 degrees, closely parallel with that of Brisbane and Moreton Bay. The corresponding Queensland type, although most abundant farther north, is also indigenous to Moreton Bay; and it is a matter worthy of investigation whether this species might not be profitably collected, or even cultivated, for the sake of both its shell and pearls, throughout the Queensland seaboard. In the wholesale market, this black-bordered mother-of-pearl shell is sold under the title of "Black-edged," while in the retail or shell-cutting trade it is technically known as "Black Scotch," and it therein commands a price of from £65 to £70 per ton.

A black-edged mother-of-pearl shell of almost identical shape and texture, but of very much larger size than the Australian variety, is procured from the Polynesian islands generally, and is known in the London market as "Tahiti Black." Its weight and dimensions are often equal to those of the largest white. At occasional intervals, when a craze for black or "mother-of-pearl" buttons has temporarily prevailed, this black shell has obtained an even higher price than the best white.

Through the courtesy of Messrs. H. Kiver & Co., one of the leading mother-of-pearl shell mercantile houses, the author is enabled to reproduce one of that firm's most recently issued reports of the shell that has passed through their hands. This report will place the reader *en rapport* with the extensive trade that is transacted in mother-of-pearl shell. It also indicates the system of classification that is adopted by the brokers, and the relative position occupied by the Queensland shell in the London market, with relation to that derived from other localities. Some of the trade terms employed in this report

demand brief explanation. The descriptions of shell placed first on the list, by way of example, under the heading of "Sydney and Queensland," represent Queensland shell exclusively. The name of Sydney, associated with it, indicates that after collection in Torres Strait it has been finally shipped from Sydney. It represents, as a matter of fact, the produce of the shelling stations belonging to Sydney capitalists established in the vicinity of Thursday Island, previously referred to. The shell denominated "Bombay" in this category, represents the ordinary black species, *Avicula furcata* (fished on account more exclusively of its pearls, on the coasts of India and Ceylon). It rarely exceeds four inches in diameter. The variety defined as "Linga" on a lower line in this list is not more than two inches in diameter, and represents the young of the "Bombay" shell. The "Shark's Bay" shell, derived from the bay of that name in the most southern pearl-shell-producing district of Western Australia, is a stunted variety of both the largest white species and a small yellow-shelled one, identical in both instances with shells that are indigenous to Moreton Bay.

The leading position occupied by the Queensland shell, with relation to that derived from all other sources, is conspicuously evident in the accompanying report. As there shown, the best quality, "fine white, selected bold," realised no less than £11 12s. 6d. per cwt. or £232 10s. per ton, against £10 17s. 6d. or £217 17s. per ton obtained for the best-quality white West Australian and black-edged Tahitan varieties. The comparison of the figures above quoted with those cited in relation to the first sale price realised at Thursday Island, and the cost of labour in the collection of the raw material, furnish the data for an approximate estimate of the possible profit which the successful conduct of pearl-shelling operations might yield.

"HENRY KIVER & CO.'S

"REPORT ON THE M.-O'-PEARL SHELL &c. SALES.

"123, FENCHURCH STREET,

"LONDON, E.C., JUNE 22ND, 1892.

"The periodical auctions were held yesterday and to-day (one-half of the catalogues being unfinished). The total quantity of White Shells, being 2,430 packages (viz., 1,558 Sydneys, against 2,184 packages last sale) and 872 packages Western Australian, against 757 packages last sale. The sales opened with considerable spirit, and prices were driven up for all White Shells, afterwards slightly relapsing. Sydney and Queensland,—Bold 2s. 6d. to 5s., medium 10s. to 15s., chicken 15s. to 20s. per cwt. dearer. Western Australian.—Bold steady to 5s. advance, thin medium 10s. to 15s., chicken 10s. to 15s. per cwt. dearer. Bombay.—Bold A's easier, B's and C's sold at steady to occasionally dearer prices, D's cheaper. Egyptian.—Bold steady, medium 5s. to 7s. 6d. better. Manilla.—Bold steady to 5s. up, chicken at 5s. to 10s. dearer. Black-edged.—Tahiti sold well at 15s. to 20s. advance for bold, and 20s. to 30s. for medium and smaller. Auckland and Fiji steady to slight advance.

"MOTHER-O'-PEARL SHELLS, &c.

"SYDNEY AND QUEENSLAND.—1,558 packages offered and about 1,500 sold; fine white selected bold £11 12s. 6d., fine bold £9 to £9 10s., fair to good rather wormy backs £8 to £9, ditto part yellow-edged £7 7s. 6d. to £7 15s. per cwt. Thin medium part yellowish to good £10 to £10 17s. 6d., chicken £10 7s. 6d. to £10 15s., bold wormy defective 87s. 6d. to 107s. 6d., broken pieces £7 5s. to £7 17s. 6d., and dead 50s. to 95s. per cwt.

"WESTERN AUSTRALIAN.—872 packages offered and nearly all sold, good bold and medium at £7 to £7 17s. 6d., heavy bold at £6 2s. 6d. to £6 15s., fair to good thin medium at £10 to £10 17s. 6d., fair to good chicken at £10 5s. to £10 17s. 6d., wormy and defective pickings at 77s. 6d. up to 102s. 6d., broken and pieces 147s. 6d. to 155s., dead middling to good dead 35s. up to 80s., low rotten at 13s. per cwt.

"BOMBAY.—About 600 packages were offered and mostly all sold, heavy bold 95s. to 102s. 6d., fair to good bold £5 10s. to £5 15s., good to fine medium £6 12s. 6d. to £7, thin small 90s. to 97s. 6d., medium and small £5 17s. 6d. to £6 10s., oysters 65s. to 67s. 6d., broken 55s., and pickings 16s. to 45s. per cwt.

"EGYPTIAN.—413 packages were offered in auction and 355 sold, good bold 105s. to 110s. per cwt.; ordinary stout ditto, 85s. to 87s. 6d.; good medium, 105s. to 112s. 6d.; small, 87s. 6d. to 97s. 6d., and oysters 57s. 6d. to 65s. per cwt.

"ZANZIBAR.—35 packages offered and 10 sold at 34s. per cwt. for yellowish small and oyster.

"LINGA.—879 packages, chiefly Persia, offered and 480 sold, fair stoutish small, 18s. to 21s. 6d., ordinary 14s. to 16s., and common 10s. per cwt. 262 bags Ceylon withdrawn

W. Saville-Kent, Photo.

London Stereoscopic Co. Rep.

HURRICANE-STRANDED CORALS, FRINGING REEF, PORT DENISON.

"MANILLA.—419 cases offered and 234 cases sold, fair to good bold £7 17s. 6d. to £8 5s., chicken £6 2s. 6d. to £7, and bold defective 87s. 6d. to 95s., and broken pieces £5 5s. to £5 10s. per cwt.

"PENANG.—77 packages offered and 60 sold, ordinary heavy bold and medium £6 12s. 6d. to £7, fair ditto £7 10s., medium and chicken £7 to £7 2s. 6d., and wormy and defective 75s. to 80s. per cwt.

"MACASSAR.—107 packages offered and 74 sold, heavy bold and medium £7 2s. 6d. to £7 10s., yellow ditto £7, ordinary yellow chicken £6 10s., one lot fine chicken £9 15s., and wormy and defective 75s. to 80s. per cwt.

"SHARK'S BAY.—1,051 packages offered and 928 sold, good stout 55s. to 65s., fair 35s. to 42s., ordinary thin 30s. to 33s., and common 10s. 6d. to 25s. per cwt.

"PANAMA.—865 bags offered, and only about 150 sold, fair to good 50s. to 55s., and ordinary defective 40s. to 44s. per cwt.

"BLACK EDGED.—1,253 packages offered and mostly sold; Tahiti, good stout bold £9 15s., good medium £10 7s. 6d. to £10 17s. 6d., small £9 12s. 6d. to £9 17s. 6d., thin small £7, small and oyster £5 10s. to £5 15s., oyster 80s. to 82s. 6d., oyster and broken £5 5s. to £5 15s., pieces £5 10s. to £5 15s., and pickings 40s. to 57s. 6d. per cwt. Good bold Auckland £5 7s. 6d. to £5 10s., medium £5 2s. 6d., and small 77s. to 85s. per cwt. Bold Fiji sold at 67s. to 75s., medium 65s., and small 50s. to 52s. 6d. Mixed medium and small Banda sold at 45s. to 49s. per cwt.

"GREEN SNAIL SHELLS in large supply, and 1,110 packages were offered and 961 sold at lower prices, especially for bold, which were 3d. to 4d. per lb. lower. Fine bold Singapore sold at 10d. per lb., ordinary to good $7\frac{1}{2}$d. to $8\frac{1}{2}$d., ordinary heavy ditto $6\frac{1}{2}$d. to $6\frac{5}{8}$d., medium $6\frac{1}{4}$d. to $6\frac{3}{4}$d., and small $1\frac{3}{4}$d. to $2\frac{1}{4}$d. per lb. Good bold Penang sold at 10d. to 11d., boldish medium $8\frac{1}{8}$d. to $8\frac{1}{2}$d., small ditto $5\frac{1}{8}$d. to $6\frac{1}{2}$d., and small $2\frac{3}{8}$d. to 3d. per lb.

"JAPAN EAR SHELLS.—524 cases offered and about half sold at very steady rates, in some cases dearer for fine. Fine trimmed 72s. 6d. per cwt., good ditto 55s. to 57s. 6d., fair 35s. to 39s., and low to ordinary rough 11s. 6d. to 29s. per cwt.

"MUSSEL SHELLS.—382 offered and 259 sold at rather dearer prices. Fair small with some medium and bold sold at 45s. to 47s. 6d., and good bold at 60s. per cwt.

"HENRY KIVER & Co.,

"BROKERS."

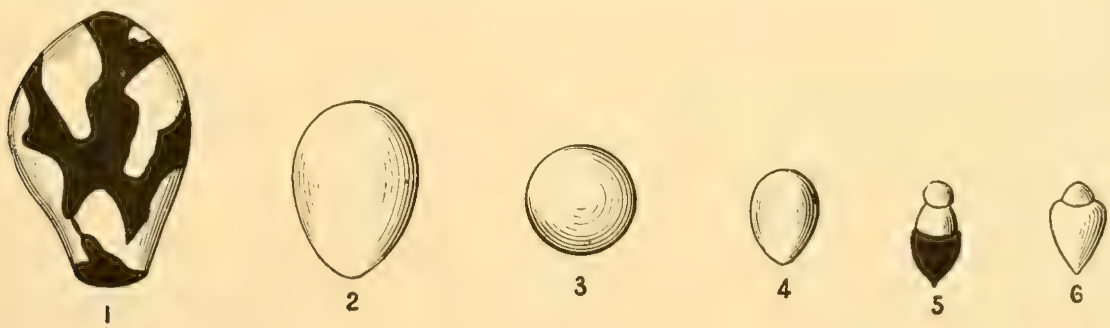
The present state of the technical nomenclature of the mother-of-pearl shells is by no means satisfactory. The single name of *Meleagrina margaritifera* is indifferently applied, in both standard conchological works and the most important museum collections, to undoubtedly two, if not three or four, distinct species. Associating the large white shell, with its yellow-edged, pale-pink, iridescent, and extra-tropical, dwarfed modifications already referred to

as local varieties only of the same typical species, it is impossible to those possessing an intimate acquaintance with the life habits and aspects of the respective forms, as they occur in their native seas, to assign to the "Black-edged" shells the same subordinate position. Facts associated with both their structural features and their areas of distribution substantially favour the recognition of one distinct species, if not two, in this black-edged race. Among the structural distinctions, it may be observed that it is a constant character in all black-edged shells, large or small, to develop a contour in which the longer axis obtains in the vertical measurement from the hinge to the opposite pallial border. In no example among a very large series examined is a longer measurement associated with one taken at right angles to the foregoing, and consequently parallel with the hinge line. In the white races, on the other hand, a longer horizontal measurement commonly obtains, and is more particularly conspicuous among the largest shells. The proportions maintained in the two series are, as nearly as possible, converse to one another, being in the respective orders of 5 to $4\frac{1}{2}$ inches in small shells, and 10 to 9 inches in large ones. A prominent feature of the black-edged shell is that it is very distinctly marked externally with vertical stripes, which gradually increase in width from the umbo to the periphery. These markings, most conspicuous in young shells, are distinct in the largest Australian examples, measuring six or seven inches in diameter. These characteristic markings are altogether absent from the typical white *Meleagrina margaritifera*, whose shells, when matured, are of a uniform light brown. The black-edged form occurs abundantly on the reefs on planes higher above low-tide mark than those inhabited by the white race, and, also, attains to its full-sized development in latitudes such as Moreton Bay, where the white race exists only in a very dwarfed condition. These facts are, in the author's opinion, amply sufficient to establish the specific distinctness of the black-edged mother-of-pearl shell on a much sounder basis than that on which a very considerable number of shell-species have been founded by conchologists; and, it being highly desirable, for the purposes of scientific nomenclature and for commercial and legal distinction with relation to the Fishery Acts,* that it should be associated with an independent specific title, it is herewith

* In the Queensland Act, 55 Vict., No. 29, recently passed, in accordance with the author's recommendations —providing for the conservation of the young, immature shell, and for the granting of leases of foreshore areas for pearl-shell cultivation,—only one species, *Meleagrina margaritifera*, is referred to. The black-edged form, which never attains in Queensland waters to the dimensions of the white shell, is not intentionally included by the Act named in the same size limits, but has to be so long as the technical name of *Meleagrina margaritifera* remains associated with both of these very distinct species. When approving of the rough draft of the Bill, now become law, it was presumed by the author that the specific title of *margaritifera* included only the large white-shelled form; and, whilst it was not found possible at the time to identify the black-edged type with any defined species, it was presumed that it had already been distinctively recognised. Consultation, however, with the British Museum specialist, Mr. Edgar Smith, and a reference to the fine collections of that institution, elicited the fact that the recognition of the black-edged shell as a distinct species had not been conceded,—evidently, in this instance, through the absence of authoritative information concerning the growth-habits and distribution of this particular shell. Its recognition as a distinct species is now imperative, if only in the interests of the legal interpretation and the just administration of the Queensland Act.

proposed to distinguish it by that of *Meleagrina nigro-marginata.* It is an open question whether the large Polynesian black-edged variety (commercially known as the "Tahiti shell") must not be regarded as specifically distinct from the smaller Australian form. It is, at any rate, significant that in the equatorial region of Torres Strait, where the white shell attains its maximum dimensions of a foot or more in diameter, the black-edged species never exceeds a diameter of six or seven inches; yet, among the South Sea Islands an (except for size) indistinguishable form may equal the dimensions of the largest Torres Strait white variety. The definition of the black-edged form as the type of a separate species is, at all events for the present, associated only with the medium-sized Queensland shell.

A reference to the size and the fine quality of the pearls produced by Queensland mother-of-pearl shells was made in a preceding chapter, p. 58, the reference being directly connected with the examples photographically illustrated in Plate XXXVII. There are herewith given wood-block delineations of some half-a-dozen Torres Strait specimens of abnormal size, shape, or composition, that fell within the author's notice during his recent Queensland journeyings.



QUEENSLAND PEARLS.

NATURAL-SIZED OUTLINE ILLUSTRATIONS OF REMARKABLE PEARLS OBTAINED FROM TORRES STRAIT.

1. Large nodular black and white pearl; weight, 84 carats or 336 grains; the black portion composed of material identical with that of which the hinge is constructed. This remarkable specimen is, or was originally, the property of Mr. John Davis, the Mayor of Cooktown. 2. Large pear-shaped pearl; weight, 40 carats or 160 grains; the value of this specimen depreciated in consequence of a slight blemish on one side. 3. Perfect spherical pearl; weight, 22 carats or 88 grains; the first price for which this pearl was sold was £400. 4. Pear-shaped pearl; weight, 6½ carats or 28 grains; valued at £100. 5. Irregular acorn-shaped pearl, the basal portion, representing the cup, being of a dark-brown hue. 6. Conical or drop-shaped pearl, suitable for a pendant.

In addition to pearls, some living organisms of interest are occasionally found within the mother-of-pearl shells when freshly opened. One of these is a little brown spherical crab belonging to the genus Pinnotheres, which very nearly resembles the mussel-inhabiting Pea-crab—*Pinnotheres pisum* of the British seas. A second Crustacean that occurs rather abundantly under corresponding conditions, in living pearl-shells in Torres Strait, more resembles a little trans-

parent pink-spotted lobster, and has been identified for the author by Dr. Henry Woodward, F.R.S., of the British Museum, as the *Alpheus avarus* of Fabricius. Figures of these two interesting "commensals" are delineated in Figs. 12 and 13, respectively, of Chromo plate No. XIV. A small, transparent, eel-like fish, Fierasfer, which occurs similarly as a commensal within the mother-of-pearl shells of the Western Australian fisheries, does not appear to frequent those of Torres Strait. An allied species, however, as recorded in the succeeding chapter, takes up its abode within the body-cavity of a Barrier Reef Bêche-de-mer. Dr. Woodward, the authority on Crustacea above quoted, published a few years since (*Proceedings of the Zoological Society*, 1886) an interesting account of a commensal Pea-crab, Pinnotheres, that was found entombed within the nacre of a Western Australian pearl-shell. In the national collection there is an example of a fish, Fierasfer, from the same colony, similarly embedded. In both instances it may be surmised that the commensal organisms died within the mantle-folds of the Meleagrina, and that the mollusc, being unable to eject their dead bodies, enshrouded them.

EXPERIMENTAL OPERATIONS.

Among the most important undertakings during the author's investigations of the mother-of-pearl shell fishing grounds of Torres Strait was that of ascertaining by direct experiment if it were not possible to bring pearl-shell alive from the outer grounds, and to lay it down and cultivate it in the shallower water adjacent to the shelling stations; also, with the same object in view, that of acquiring a much-needed information concerning the development and habits of this valuable mollusc. It was thought that, should the proposed operations prove capable of practical application, a very much more extensive and permanently profitable development of the pearl and pearl-shell fisheries would be rendered feasible; it being difficult indeed to predict the far-reaching limits to which they might be extended.

Up to the date of these investigations, the most contrary views were prevalent among those engaged in the shelling industry, concerning the life-history and natural habits of the mother-of-pearl shell, *Meleagrina margaritifera;* while little or no credence was attached by them to the possibility, suggested by the author, of bringing in the shell alive and cultivating it artificially. By way of illustrating the variety of opinions that were upheld: It was affirmed by many of the pearl-shell divers that the mollusc remained permanently fixed in its ocean bed through every stage of its existence. By others it was asserted that the shell had no means of attaching itself, but that at the same time it remained permanently quiescent in its selected habitat. By yet a third section, it was as strenuously maintained that the pearl-shell was a migratory animal that was constantly moving from place to place. Had this last-named theory proved to be the correct one, all attempts at artificial cultivation would have necessarily been failures; the impounded shells being liable, after the manner of scallops, genus Pecten, Lima, and other allied types, to take

unto themselves wings and flee away. As the experiments demonstrated, none of the three theories was in precise accord with the facts.

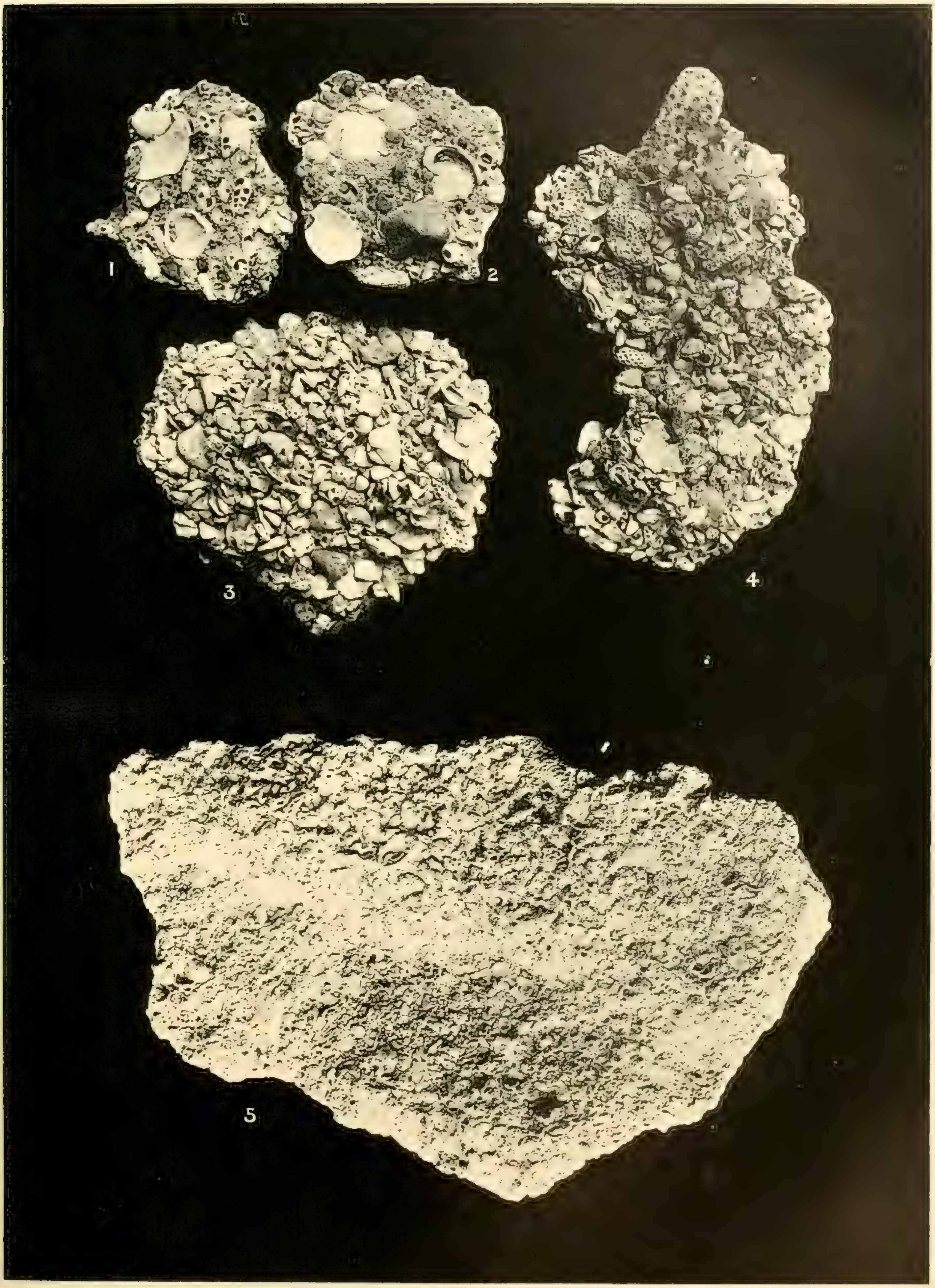
By a fortunate coincidence, the author arrived at Thursday Island, on his first official visit, August 6, 1889, at a period that enabled him almost immediately to acquire important information concerning the life-habits of this shell-fish. A few weeks previously, a diver who had been employed to examine the bottom of the storage hulk, *Star of Peace*, with a view to repairs, found growing upon it a quantity of shells which were pronounced by him to be the young of the true pearl-shell. No attempt was made to keep the shells alive. They were merely dried and cleaned, and in that condition submitted to the author for examination and identification by the Hon. John Douglas, the Government Resident at Thursday Island. The majority of the examples gathered were evidently the young of *Meleagrina margaritifera*. Mixed with them, however, were the young of the smaller black-lipped species, here distinguished by the title of *Meleagrina nigro-marginata*, and also those of a third non-commercial species not yet precisely determined, but apparently corresponding with *Meleagrina muricata*. These shells, gathered from the *Star of Peace*, varied from one inch to three inches in diameter. Within the next few days, while exploring the coral-reefs in the immediate neighbourhood of Thursday Island at low spring-tide, the author obtained several similar young living examples of the true mother-of-pearl shell, *M. margaritifera*. The smallest of these measured no more than a quarter of an inch, and the largest about two inches, in diameter. These shells were in all cases attached to the under surface of loose coral-rocks by a cable or byssus consisting of a bundle of tough green threads. By severing this byssus carefully with a knife, the author secured the shells without the slightest injury. They were brought in and kept alive for a study of their habits. Efficient aquaria for their conservation were extemporised out of two huge clam-shells, *Tridacna gigas*—each having a capacity of several gallons—that ornamented the lawn of the Government Residence. Sea water was brought up in buckets from the shore, and renewed to them every day ; the little pearl-shells adapting themselves with remarkable alacrity to the novel environment. About a dozen individuals, to which others were subsequently added, were maintained in health for several weeks under the conditions just described, and afforded the opportunity of observing and recording many important data.

It was first observed that these young pearl-shells possessed the capacity of ejecting the portion of the byssus remaining embedded in their tissues after they were separated from their primary attachment, and of secreting a new byssus, by which they affixed themselves to the nearest available anchorage. The latter was furnished, in the specimens under observation, by the inner of the clam-shells in which they were confined. In very nearly all instances the re-attachment of the shells was effected to the immediate spot upon which they were placed when brought in from the sea, to which anchorage they remained firmly fixed throughout the period of their confinement. The exceptional cases were furnished by certain of the

smallest shells, one or two of which crept from the upper and re-attached themselves to the shaded under surface of an empty oyster-shell, upon which they had been placed. A specimen in another instance removed itself for the space of a few inches before re-attaching itself by its new byssus. Two of the smallest examples, about a quarter of an inch diameter, which were temporarily kept in a wide-mouthed bottle, were observed to creep with the aid of their slender protrusible feet a little distance up the side of the bottle, to which they then made themselves secure by the secretion of a byssus. This byssus, or anchoring-cable, is secreted a thread at a time. During its exudation it is of the consistence of liquid glue; but it rapidly hardens in the water. The byssus of living examples of the true pearl-shell, *Meleagrina margaritifera*, was, in all cases observed, whether young or old, of a glossy sea-green hue; the number of threads or strands of which the entire cable is composed are usually from thirty to forty. It may be mentioned that the extemporised aquaria, represented by the large clam-shells, in which the young pearl-shells were confined, were located on the hillside immediately in front of the Residence. They were thus fully exposed to the action of the south-east monsoon, which, at the period of the experiments conducted, August and September, blows strongly and continuously. By this means the thorough oxygenation of the water in which the shells were kept was constantly secured. The only additional precaution taken for the welfare of the little Meleagrinæ was the placing of a board over the top of the clam-shells to screen the water, with its living contents, from the direct rays of the midday sun.

The facts that were determined by the experimental culture of the young shell may be thus summarised: 1. It was conclusively demonstrated that the pearl-shell, in its young condition at least, firmly attaches itself to submarine objects by means of a so-called byssus or anchoring cable. 2. That, in the event of injury, the primary byssus could be ejected and a new one secreted. This fact carried with it the demonstration that the animal was capable at will of separating itself from its original fulcrum, and of re-attaching itself elsewhere. 3. Whilst the young animals were found to possess the capacity of locomotion, such locomotion was shown to be of a feeble character and but rarely exercised. In this respect the habits of the pearl-shell were found to coincide, to a considerable extent, with those that have been observed of ordinary mussels, genus Mytilus, and the typical wing-shells, genus Avicula. Active locomotive functions similar to those of the scallop-shells, genus Pecten, and an allied type, genus Lima,—both of which can transport themselves to considerable distances by the opening and closing of their valves,—are certainly not possessed by the pearl-shell, *Meleagrina margaritifera*, and have been incorrectly ascribed to it by divers and owners of shelling boats.

The information gathered concerning the habits of the young pearl-shell was next extended to those of the more matured, and of adult, individuals. This was accomplished chiefly through the acquirement of materials obtained in an excursion, made in the Q.G.S. *Albatross*, to one of the most prolific shelling grounds in Torres Strait, lying west from Bado or Mulgrave



W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

SPECIMENS OF CORAL-ROCK CONGLOMERATES.

Island, and familiarly known to the fishermen as the "old ground." Some forty vessels, luggers of ten or eleven tons burden, were engaged in shelling operations on the area traversed by the *Albatross*. The majority of these were boarded, the methods of working observed, materials collected, and much practical information elicited from the divers. It was found in this connection that all the medium pearl-shells—up to a diameter of seven or eight inches—were attached, in a similar manner to the young ones already described, by a strong byssus or anchoring cable, to a supporting fulcrum, this fulcrum consisting chiefly of the fragments of coral and shell, of which the sea-bottom is here composed. The shells of larger size, nine or ten inches in diameter, and of considerable weight, from 5 to 6 lb., were, in all examples examined by the author, devoid of a byssus, and rested simply on their ocean-bed. A similar condition was observed in several large shells which the author personally collected at extreme low tide on the "Warrior" and other outlying coral-reefs. Such adult shells evidently require no cable to keep them anchored in the tideway, their own weight insuring their stability; this is in many instances further secured by the luxuriant growth upon their exposed upper shells (usually the right valve) of heavy Madrepores and other corals, such as the well-known Cup-corals, *Turbinaria patula* and *peltata*, and innumerable varieties of sponges, shells, seaweeds, and other organic growths. Under such a combined weight it would be altogether impossible for the animal to move, and the question of its migratory habits, previously suggested, may, in face of the evidence here adduced, be most distinctly answered in the negative. Many young shells, corresponding in every essential detail with those referred to as having been obtained from the bottom of the *Star of Peace*, were found adhering to adults. These young shells were saved alive, in company with a series of matured specimens, for further investigation.

The question will not improbably present itself why large pearl-shell was not found adhering with the young ones to the bottom of the *Star of Peace*. The periodical cleaning would necessarily prevent them from arriving at maturity in such a position. There is, at the same time, every reason for believing that as soon as they attain to a certain size and weight they literally slip their cable, and subside to the bottom of the water, or, probably, drift with the current to a considerable distance. This capacity to detach themselves was fully proved by the specimens kept in confinement. The presence of many an abandoned cable or byssus on the older shells collected from the hulk further supports the foregoing interpretation. Mature shells, from which the young ones adhering to the *Star of Peace* were probably derived, are said to be abundant in the channel in which the hulk is moored; but the currents are too strong to permit of their being profitably worked.

One of the most important purposes of the expedition was to ascertain, by direct experiment, if it was possible to bring the pearl-shells in alive from the outer fishing grounds, and to relay and cultivate them in the shallower, inshore, waters. The evidence hitherto adduced was not favourable to this scheme, the majority of the witnesses interrogated maintaining that the shells would

not survive removal from their native habitat, and that attempts previously made to transport the shell had failed. In order to test the matter, several distinct methods were resorted to. Some fifty examples, varying from five or six to as much as ten inches in diameter, were placed at the author's disposal by the different boats. The majority of these specimens were immersed in two tubs of sea-water, on board the *Albatross*, the water being run off and renewed to them every three or four hours. At night, when the ship was usually at anchor, the shells were taken out of the tubs and placed in specially-constructed cages, composed of wire netting stretched over rhomboidal wooden frames, this shape offering the least resistance to the current. The frames, with their contents, were then lowered overboard, and secured by a rope until the morning. A few specimens, some half-a-dozen only, were simply placed in a shady spot on deck, sea-water being thrown over them at intervals. With a third equally small series, an experiment was put into practice, identical with the method recently reported to have been attended with remarkable success in connection with the conservation of the American oyster for long periods out of water. This method, known as "muzzling," consists of fastening the shell so tightly together with wire that the liquids cannot escape. Thus treated, the oysters are said to survive several weeks' isolation from their native element. All the pearl-shells treated in the several manners described were brought into Thursday Island on the second day after their collection. Of the examples confined in tubs of sea-water, renewed at intervals throughout the day, and lowered overboard in frames at night, every specimen was preserved in perfect health. Of the number simply placed in the shade on deck, sea-water being occasionally thrown over them, one-half only arrived in good condition; while the remaining half, being too exhausted to recover, fell a speedy prey to crabs and predatory molluscs. A like untimely end befell all those examples upon which the muzzling process had been practised. A subsequent study of the case last recorded showed that the mortality was brought about through the liquid draining away entirely from the animals through the byssal or pedal cleft, which retains its full development even in the adult shells, by which a byssus is no longer secreted. A like explanation applies, in a less marked degree, to the specimens left on deck, over which water was thrown at intervals. The above described experiments clearly demonstrate that the mother-of-pearl shell, whilst of a much more delicate constitution than the ordinary oyster, and very impatient of prolonged isolation from its native element, might, with due care, and under conditions corresponding with those to which the bulk of the specimens were submitted—namely, continual immersion in sea-water,—be easily transported in a living state from the outer fishing grounds to any desired locality.

The next step taken was to ascertain the practicability of cultivating the pearl-shell brought from the outer fishing grounds, from a depth of seven or eight fathoms, in the comparatively shallow inshore waters. Some favourable-looking pools in the fringing coral-reef off Vivien Point, immediately beneath the Government Residence of Thursday Island, were selected. These pools, which were exposed only for a few hours during the lowest ebb of the spring-tides, proved

to be admirably adapted for the purpose. At all other times a strong current, which is one of the most essential desiderata for healthy growth of the animals, swept over them. Corals of the genus Madrepora, which will flourish in the purest and swiftest circulating water only, were growing freely in these pools; and the conditions generally coincided closely with those under which the pearl-shell was in former times abundantly, and may even yet be occasionally, gathered in its adult state. For greater security, and in order that they might be more readily accessible for examination at all tides, the forty adult and about equally numerous young oysters that had been brought in by the *Albatross* were placed in wire-netting-covered wooden frames, closely resembling those which had for some years previously been successfully employed by the author for the culture of ordinary oysters. In these frames the shells were raised slightly from the surface of the ground, and they at the same time remained covered by a few inches of water, at even the lowest ebb of the tide. Examined at short intervals throughout the remaining period of the author's stay at Thursday Island (about six weeks) all the specimens were found not only to be doing well, but to be growing rapidly. By the end of this short period, some of the examples had added as much as half-an-inch to the free borders of their shells, and in almost all instances lappet-like prolongations of new shell were produced at this growing region. A corresponding rapidity of growth was observed for the young shells having a diameter of two or three inches only, including both those acquired in connection with the *Albatross* expedition and the specimens previously obtained from the adjacent coral-reef.

Several examples from the stock of pearl-shell accumulated, were dissected, for the purpose of preparing a diagram of the animal's anatomy; and others were sacrificed with the object of ascertaining the capacity possessed by the living animals of repairing their shells when mutilated, and the time occupied in that process. The results tended to show that the growth and maturation of the pearl-shell is effected within a much shorter period than has been suspected. By many of those practically concerned in the pearl-shell fishery, a period of from ten to fifteen years has been variously assigned to the mollusc, as the time required for the growth of its shells to a marketable condition. Until the species has been under cultivation or continuous observation for years, it will be impossible to determine this important point. From the investigations then and subsequently conducted, and from data otherwise collected, the author is inclined to think that under favourable conditions a period not exceeding three years suffices for the shell to attain to the marketable size of eight or nine inches diameter, and that heavy shells of 5 lb. or 6 lb. weight per pair may be the product of five years' growth. In connection with the experiments concerning the artificial cultivation of the pearl-shell, it was the author's desire to make himself acquainted with the reproductive phenomena of the species, of which up to that time no accurate information was available. In none of the specimens dissected, nor in the more numerous examples opened on the shelling grounds, however, were the reproductive organs mature. From this it is thought that the principal spawning season of this mollusc occurs during the calmer and hotter period of the

north-west monsoon. As evidence in support of this conjecture, it may be mentioned that a few specimens, examined later, were found on dissection to have their reproductive organs in a more matured condition.

As a general result of the experiments and investigations, it may be confidently predicted that, if encouraged by favourable concessions and aided by skilled technical supervision and advice, the artificial cultivation of the mother-of-pearl shell, on a system akin to that applied to ordinary commercial oysters, will in the near future be a very important and profitable branch of the Queensland fisheries, giving an entirely new impetus to the pearl and pearl-shelling industry as at present constituted. Under existing conditions, the majority of the shelling companies and shelling-station owners are reaping a scanty return for their investments. This is mainly a consequence of the heavy costs attending the collection of the shell, and the considerable intervals of bad weather during which the work cannot be prosecuted, the expensive maintenance of the boats and crews remaining, meanwhile, undiminished. Facilities being by the recent Act conceded to station-owners, to the extent of granting them durable leases of the land they occupy for the prosecution of their business,—such leases including the right to utilise a certain extent of the foreshore or water area in the vicinity of their stations for the formation of pearl-shell beds, with the right also to select and rent any other suitable areas, within certain limits, for a like purpose,—a substantial increment to the profits of the pearl-shelling fishery is now attainable. Under these new auspices it would be to the advantage of the station-owners to arrange with the divers to bring in a certain amount of undersized living shell every trip they make. This (by a clause in the new Act suggested by the author) they are (whilst restricted from placing it on the market as dead shell) fully entitled to do. By bringing in even a small number at a time, the constantly recurring trips of several boats would soon accumulate a stock of shell which after an interval of two or three years would become a very valuable property. Requiring no expenditure in its maintenance, it would continually multiply and increase in value. Such artificially accumulated beds, when once matured, would permit of an annual output, which would add materially to the profits of the ordinary fishery and yield other substantial advantages to the proprietors. The shell raised on such home stations would, as a matter of business, be opened by, or in the presence of, the boat owners or managers, and the pearls, which have hitherto been appropriated more or less completely by the divers and boats' crews, would revert to their rightful proprietors. In conjunction with the establishment of the suggested home shell-beds, it would probably be found sufficient to keep the boats at work on the outer grounds only during the most favourable months, of the year. Such an arrangement, if feasible, would very materially lessen the present annual cost of production.

For the transport of living shell from the outer grounds to the home stations in any considerable quantity, well-boats, as used extensively in the European North Sea Fisheries and in

other countries for the carriage of living fish, might be advantageously employed. Under such conditions, the shells of suitable size might be accumulated at leisure, and preserved alive in the wells for many days preceding the return of the boats to port. For this special object, a slight modification of the construction of ordinary fish-wells would be desirable, brattices being introduced to keep the shell from covering the waterholes or from lying too closely upon one another. The holes drilled in the bottom and sides of the well should be larger and more numerous, so as to admit of the freest possible circulation of the water. The employment of well-boats is recommended in the foregoing paragraphs, with reference only to the transport of immature shell for the purpose of cultivation. I may, however, point out that, through the introduction of welled vessels on a more extensive scale for the freight of the ordinary shell, the station proprietors have at hand a ready remedy for the losses to which they have hitherto been subjected, through the wholesale appropriation of the pearls by the boats' crews. With the addition of one or two welled smacks to act as tenders to their fleets, each capable of carrying a ton or more of shell, the companies and proprietors owning a number of boats would be in a position to bring all the shell obtained into port, where it could be opened under their personal supervision. One year's produce of the pearls obtained through this arrangement would, it may be fairly thought, recoup to the owners the cost of the smack.

Natural facilities for the cultivation of mother-of-pearl shell exist throughout the Barrier district, and also in the Gulf of Carpentaria, although nowhere to such an extent as in the neighbourhood of Thursday Island and the associated island groups enclosing intricate series of well sheltered channels whence pearl-shell has been obtained abundantly in former years. The necessary facilities being now afforded, Torres Strait, it may be confidently predicted, will, in the near future, become as important a centre of the pearl-shell industry as it has hitherto been of the ordinary fishery for this mollusc.

Attempts were made on one occasion by the author to bring living examples of pearl-shell from Thursday Island to Brisbane, with the object, had they survived the passage, of prosecuting investigations into their habits and life-history. Had they journeyed straight through by the A.U.S.N. Co.'s steamer *Waroonga*, in which they were first embarked, the attempt would probably have proved successful. Through the courtesy of the Company's agents and the Commander, Captain Borders, a spare bath was placed at the author's disposal. The shells were put into it, and through it a stream of pure sea-water was constantly passed. Under these auspices the specimens, about a score, arrived at Cooktown in excellent condition. Here, however, the author was detained for a week or so, and the shells, being disembarked, were temporarily sunk in frames in an apparently suitable locality close to the Customs jetty. It was subsequently ascertained that the water was insufficiently saline and impregnated too extensively with sedimentary matter for their well-being,—unfortunately, not before several examples

had died, and the remainder had so deteriorated in health as to become unfitted to withstand the abnormal conditions of a journey farther south by another steamer, in which the circulating arrangements of the sea-water were less perfect than in the *Waroonga.* The last surviving pearl-shell was removed from the travelling frames on reaching Mackay, within two days' steam of Brisbane. Notwithstanding the negative results arrived at in this particular instance, sufficient evidence was gained by the experiment to show that, under more favourable conditions, the transport of the living shell from Thursday Island to Moreton Bay, or to an even greater distance, is possible.

For the information of those to whom the mother-of-pearl shell fishing grounds of Torres Strait may prove an attractive field for practical operations, an excerpt of the clauses relating to the new regulations with reference to the legal sizes of the shell, and the facilities at disposal for obtaining loans of produce areas, is herewith appended.—

"*Act* 55° *Victoria No.* 29.

"*Pearl-shell and Bêche-de-mer Fishery Amendment Act of* 1891.

"Clause 11. Any person who removes, except for the purposes of cultivation only within the colony, or sells or exposes for sale, or attempts to export from the colony, and any dealer in pearl oyster shell who purchases, any pearl oyster shell of the kind scientifically known as *Meleagrina margaritifera*, and of either of the varieties commonly known as 'golden-edge' and 'silver-lip,' of which the nacre or mother-of-pearl measures less than six inches from the butt or hinge to the opposite edge or lip, shall be liable to a penalty not exceeding five pounds for every such pearl oyster shell found in his possession, and every bag or other receptacle containing shell in which any such shell is found, and every heap or other collection of shells in which any such shell is found, shall be forfeited.

"Any person in whose possession any such shell is found shall be bound to disclose to an inspector on demand the name and address of the person from whom he acquired the same, and if he fails to do so shall be liable to a penalty not exceeding five pounds.

"Provided that if it is proved to the satisfaction of the Governor in Council that the ordinary size of any such pearl oyster shell when full grown is, when found within any specified territorial waters of Queensland, of less size than that hereby prescribed, the Governor in Council may by Proclamation direct that with respect to any such pearl-shell found within those waters other dimensions shall be substituted for those hereby prescribed: And with respect to the pearl-shell so found, the dimensions so directed to be substituted shall be deemed to be so substituted in the enactment in this section contained.

"And provided further that in the case of any such pearl oyster shell of the variety commonly called 'dwarf shell,' an inspector may, on application, at his discretion, authorise its removal or sale, or exposition for sale, notwithstanding that it is of less size than that hereby prescribed.

And the provisions of this section shall not apply in the case of any shell with respect to which such authority has been given.

"An inspector may examine any pearl oyster shells collected, carried away, or exposed for sale, and may seize any shells contained in a bag or other receptacle in which is any shell of less size than that hereby prescribed, or any heap or other collection of shells in which is any such shell.

"12. All pearl oyster shell shall be shipped for exportation at Port Kennedy, in Thursday Island, or some other port appointed by the Governor in Council for that purpose, and no such shell shall be shipped for exportation until the expiration of forty-eight hours after notice of the intention to ship it has been given to an inspector.

"An inspector may require any package containing pearl oyster shell packed for exportation to be opened, and its contents exposed to view, in his presence.

"Any person who refuses to comply with any such requisition of an inspector or who ships or attempts to ship any pearl oyster shell for exportation contrary to the provisions of this section shall be liable to a penalty not exceeding twenty pounds.

"13. The Governor in Council may, by proclamation, prohibit for a time specified in the proclamation the collecting or obtaining of pearl oyster shell of any variety, or of bêche-de-mer, from any port, bank, channel, reef or cluster of reefs, or any portion of a port, bank, channel, reef or cluster of reefs.

"Any person who obtains or collects pearl oyster shell of any prohibited variety, or any bêche-de-mer, from any place from which the collecting or obtaining of pearl oyster shell of that variety, or of bêche-de-mer, is prohibited, shall be liable to a penalty not exceeding fifty pounds, and all pearl oyster shells or bêche-de-mer in his possession may be seized by an inspector, and shall be liable to be forfeited.

"14. The Police Magistrate at Port Kennedy may grant to any person who is, in his opinion, of good character and reputation, a license to deal in pearls.

"A fee of twenty-five pounds shall be paid for the license. A license shall be in force until the thirty-first day of December next after the date of its issue, but shall be liable to be cancelled by a Police Magistrate upon the conviction of the licensee of any offence against the provisions of '*The Pearl-Shell and Bêche-de-Mer Fishery Acts*' or '*The Licensing Act of* 1885.'

"15. After the thirty-first day of December one thousand eight hundred and ninety-one it shall not be lawful for any person to purchase pearls at any place where the fishery is carried on, or at Port Kennedy, except from a licensed dealer in pearls, without having first obtained a license to deal in pearls.

"Any unlicensed person who after that time purchases pearls at any place where the fishery is carried on, or at Port Kennedy, except from a licensed dealer in pearls, shall be liable to a penalty not exceeding one hundred pounds.

"16. The Governor in Council may grant a lease of the whole or any part of an outlying reef

or bank, or of the foreshore of an island, or of any Crown lands lying below high-water mark, in any river, inlet, estuary, or creek, or any lands lying below tidal waters within the limits of the territorial jurisdiction of Queensland, for the collection, storage, cultivation, or propagation, of pearl oyster shell or of bêche-de-mer, or of sponges or other products of the sea. Such leases shall be granted under and subject to such conditions and stipulations as the Governor in Council may prescribe by Regulations.

"The Queensland Territorial Boundary Act, by virtue of which the limits over which the colony holds jurisdiction are accurately defined, may be appropriately reproduced at this point. In addition to indicating the boundaries within which leases of island foreshores for pearl-shell and other culture may be applied for and conceded, it may be advantageously referred to in association with the question of international territorial limits discussed on page 318."

"*Act* 43 *Victoria No.* 1., 1879.

"An Act to provide that certain islands in Torres Strait, lying between the Continent of Australia and the Island of New Guinea, shall become part of the colony, and subject to the laws there in force.

"SCHEDULE.—Certain islands in Torres Strait and lying between the Continent of Australia and Island of New Guinea, that is to say all islands included within a line drawn from Sandy Cape, northwards, to the southernmost limits of the Great Barrier Reefs, thence following the line of the Great Barrier Reefs to their north-eastern extremity near the latitude of nine-and-a-half degrees south, thence in a north-westernly direction embracing East Anchor and Bramble Cays, thence from Bramble Cays, in a line west by south (south seventy-nine degrees west), true, embracing Warrior Reef, Saibai and Tuan Islands, thence diverging in a north-westerly direction so as to embrace the group known as the Talbot Islands, thence to, and embracing the Deliverance Islands and onwards in a west by south direction (true) to the Meridian of one hundred and thirty-eight degrees of east longitude."

A. OUTER BARRIER REEF, WITH SUBMERGED BÊCHE-DE-MER.

W. Saville-Kent, Photo. London Stereoscopic Co. Rep.

B. LADY ELLIOTT ISLAND REEF, WITH SUBMERGED BÊCHE-DE-MER.

CHAPTER VI

BÊCHE-DE-MER FISHERIES.

BÊCHE-DE-MER, Sea-slugs, Sea-cucumbers, or Trepang, as the reef-frequenting animals dealt with in this chapter are variously designated, represent an ordinal group, that of the Holothuridæ, which belongs systematically to the class of the invertebrate sub-kingdom which is distinguished by biologists under the title of the Echinodermata. The term *Bêche-de-mer*, by which the organisms are now most generally known in trade circles, is the French form of the older title of *Bicho-do-mar*, signifying a sea-worm or sea-slug, which was suggestively applied by the older Portuguese navigators to that marine produce which from the earliest times has constituted so important an article of commerce in China and the Malayo-Polynesian region generally, where it is better known under the colloquial title of *Trepang*. *Sea-slugs* and *sea-cucumbers* are Anglo-Saxon titles, having reference to the general shape of the animals, and they have been applied popularly to various allied species, mostly smaller, and having no commercial value, which are indigenous to British waters.

The class of the Echinodermata includes, in addition to the ordinal group of the Holothuridæ, or Bêche-de-mer, all the innumerable varieties of star-fishes and the spine-bearing sea-urchins or Echini. The fundamental structure in each of these orders is identical. This may be most readily understood by an examination of their organs of locomotion, which are found, in each of the allied groups mentioned, to consist of a series of extensile tubular organs, "ambulacra," which terminate in adhesive suctorial disks, and are not possessed by any other class of the animal kingdom. The representatives of the Holothuridæ, or Bêche-de-mer, are distinguished from their allies, the star-fishes and sea-urchins, by their elongate, somewhat cucumber or sausage-shaped bodies, which are capable, in all the commercial forms, of great contraction and extension The mouth, which is situated at one extremity of the body, is surrounded by a series of plumose or tufted tentacles; a circular or pentagonal aperture at the opposite end is the vent.

The food of Bêche-de-mer consists chiefly of the microscopic calcareous-shelled animals known as Foraminifera, which are swallowed in combination with a large percentage of sand and broken fragments of shells and corals. The process of feeding, as observed by the author in a large number of varieties, is in all cases identical, and somewhat remarkable. The tufted, moplike, tentacles are one by one swept over the surface of the ground, or reef, upon which the animal is feeding, and in corresponding order they are recurved towards the mouth, and thrust with the adherent food-matter down the creature's throat; in reverse order they are extended to annex more pabulum. The largest-sized commercial Bêche-de-mer obtained from Queensland waters is the ordinary "prickly-fish" or "prickly-red," *Stichopus variegatus*, which, in its fully-extended state, may measure four feet or more in length, with an accompanying diameter of four or five inches. Eighteen inches is the more ordinary extended length of black, red, and teat-fish. In all instances these organisms are capable of contracting to about one-half of their extended length, the body under contraction becoming, of course, thicker.

The process by which Bêche-de-mer is prepared for the market, in Queensland, is as follows: The "fish" are first collected in sacks by wading or diving off the reefs during the low spring-tides. They are then, immediately on their arrival at the depôt or curing-station, placed in large iron caldrons, and boiled for twenty minutes. They are next taken out; split up longitudinally with a long, sharp-pointed knife; gutted; and exposed on the ground in the sun until the greater portion of the moisture has evaporated. The largest specimens, such as prickly and teat-fish, are frequently spread open, so as to dry more readily, with small transversly-inserted wooden splints. The greater amount of moisture having been got rid of, the fish are transferred to the smoke-house. This is usually composed of corrugated iron, 10 feet or 12 feet high, and fitted, in its upper half, with two or three tiers of wire netting, upon which the Bêche-de-mer are laid. The wood most in favour for the smoking process is that of the red mangrove, *Rhizophora mucronata*. Twenty-four hours is the usual period for which Bêche-de-mer are left in the smoke-house. By the end of that time they have for the most part shrunk to a length of six inches or less, and in aspect they may be likened to charred sausages. They are then ready for bagging up and despatch to the nearest market.

An essential matter that demands the most careful attention of those engaged in the Bêche-de-mer fishery is the maintenance of the cured fish in a thoroughly dry condition. The prepared produce readily absorbs moisture; should it get wet, or have been insufficiently cured, it has a tendency to dissolve into a tenacious, glue-like, mass of the most repulsive aspect and abominable odour. Properly cured and maintained in a first-class condition, the dried animals (to use a trade expression) should rattle like walnuts in their bags. To insure their delivery in the Hong Kong market in the same prime condition, the precaution is sometimes taken of transporting them in tin-lined cases.

The fishery for Bêche-de-mer is carried on chiefly by means of small luggers of five or

six tons burden. These make daily voyages from the curing-station to the neighbouring reefs, which are exposed only at low water; or a fleet of them may remain in the vicinity of the reefs, one or more acting as tenders to convey the fish to the curing-station, and to bring back supplies. A few large schooners or other ships, of from twenty to forty or fifty tons, are fitted out from both Thursday Island and Cooktown, which carry on board with them smoke-houses, small boats, and all the appliances requisite for collecting and curing. These craft shift their anchorage from place to place among the reefs, sending their boats in all directions to collect the fish. The crews employed in gathering the Bêche-de-mer consist chiefly of mainland aborigines, or "Binghis," as they are termed in the North, with a frequent admixture of Torres Strait and South Sea Islanders and Manilla men; these latter are frequently entrusted with the command of the separate boats. The natives of New Guinea were formerly employed extensively in this fishery, and proved to be very industrious and profitable workmen. For the craft licensed from Port Kennedy, Thursday Island, the aboriginal crews are recruited to a large extent from the Batavia River, in the Gulf of Carpentaria; the crews employed on the boats fitted out from Cooktown are derived chiefly from the east-coast districts. The annual licence fees, payable in Queensland, are similar to those of the pearl-shelling industry, and are as follows: For every small boat, 10s. per annum; for every ship or lugger up to ten tons burden, £3, and an additional 10s. per ton for every ton over this measurement; £20, however, represents the highest fee payable. All aborigines employed in the Bêche-de-mer fisheries have to be brought to the nearest port for registration and for discharge before the shipping master; for which formality, in the former instance, a fee of 2s. 6d. per head is charged. The wages earned by these aborigines range from 5s. to 20s. per month, with all rations provided, 10s. representing the most customary one. These wages are invariably paid in kind, goods to the amount earned, consisting chiefly of clothing and tobacco, being usually selected. The lowest wage named, that of 5s. per month, is earned by the women, or "gins," who accompany the men engaged, and at many of the curing-stations are employed mainly in cleaning and preparing the Bêche-de-mer for the smoke-house. A highly characteristic illustration of this stage of the curing process is afforded by the photographic view reproduced in Plate XXXVI., wherein the natives, chiefly women, of Warrior Island, Torres Strait, thus busily employed, are surrounded by the not very elaborate paraphernalia of their craft. A good average take for a station on the Barrier fishing grounds, working (say) with only four boats, carrying collectively twenty to twenty-four men, is one ton of cured Bêche-de-mer per month. Two tons per month, with the same craft and number of hands, is an occasional but exceptionally abundant take. More often than otherwise, however, the full measure of a single ton is not realised. The collection of the Bêche-de-mer is accomplished during the low tides in the new and full phases of the moon, and eight or ten days in each lunar month are thus not profitably utilised. The greater portion of the Bêche-de-mer is simply picked off the

reefs when the water has receded ; but the finest red and black fish, and the prickly-fish almost exclusively, are obtained, by diving during the same low tides, from a depth of two or three fathoms.

The Bêche-de-mer fishery can be profitably conducted with a much smaller outlay of capital than that required for operating with pearls and pearl-shells. The craft employed is much smaller ; no costly diving apparatus is required, nor the hire of skilled divers, tenders, and pumping hands. As previously related, the aborigines from the Queensland mainland are extensively employed in this fishery, undoubtedly one of the few industries in which Australian native labour can be turned to profitable account. The native as a rule does not take kindly to agriculture or to any manual work of a persistent character. To fishing and hunting, however, he is "to the manner born," and there is not an employment that could be devised more to his liking than his attachment, accompanied by his wife and picaninnies, to a liberally-found Bêche-de-mer camp, with comfortable quarters, plenty of "tucker" and work which is to him almost his natural recreation. The attachment of the aborigines to fishing pursuits is practically demonstrated by the persistence with which the same families, or individuals, will year after year seek re-engagement at the hands of honest employers. Doubtless, many a tale could be told throwing discredit on their trustworthiness: tales of the massacres of station owners, of boats and stores decamped with, and of the European or Manilla "boss" being marooned on a coral islet, or left to perish on a temporarily exposed reef. There is usually, however, an obverse side to these tragic pictures, which shows that the aboriginal was not the initial aggressor. In the earlier days there have undoubtedly been many cases of natives being kidnapped and compelled to work against their will; of interference with the women; and of glaring breaches of faith on the part of the employers respecting the wages, in coin or in kind, paid over to the crews on the completion of their engagements. Injustices referable to the last-named category are not altogether unknown now; but in face of the excellent regulations rigidly enforced by the Queensland Government concerning the engagement, discharge, and payment of the aboriginal crews, all these abuses are rapidly becoming mere traditions.

A monument erected in Cooktown bears testimony to a touching tragedy in a Bêche-de-mer camp some ten years ago, in which a wild tribe of aborigines were the aggressors. The camp, in this instance, was established on Lizard Island, and was worked by a man named Watson, who resided there with his wife and child. During his absence one day with all hands, excepting a Chinese gardener, natives from the mainland attacked the camp. Mrs. Watson and the Chinaman bravely defended it, and ultimately caused the blacks to retreat. In the night, fearing that a more serious attack was contemplated, Mrs. Watson, with her infant and the Chinaman, embarked in an old iron ship-tank, all the boats being absent, and floated away in the hope of being seen and picked up by one of the passing steamers. They ultimately

reached No. 5 Island of the Howick group, where there was no water, and where they must have perished from hunger and thirst. This was only too surely proved by the discovery, only a few days later, of their bodies, together with a scrap of Mrs. Watson's writing, giving the broad details of the episode.

Little or nothing has as yet been accurately ascertained concerning the breeding habits and rate of growth of Bêche-de-mer. Fish of approximately the same size, and these mostly of adult growth, are almost invariably found upon any reef. Such reef, if apparently cleared of fish one year, is found in another year to be tenanted by fish of a similar adult growth; and it would appear from the evidence so far available, that these are continually migrating from deep water to the upper strata of the reefs. On none of the reefs investigated by the author, on which red, black, and teat-fish were collected in some abundance, were any small or young individuals obtainable, and only in the case of lolly-fish were specimens of about one-half of the adult dimensions found mingled with the others. From one informant only was evidence obtained concerning the observation of well-developed spawn, or roe, being found inside any of the commercial species of Bêche-de-mer. This observation related to the surf-red and teat varieties, in which masses of yellow spawn, resembling beef suet, had been noticed during August and September. With the majority of Bêche-de-mer, or Holothuridæ, known to science, the young are liberated in the form of multitudes of microscopic ciliated larvæ, which float, like oyster spawn, for some time on the surface of the water. In a few rarer and more exceptional deep-sea varieties, the young Bêche-de-mer are produced in a form resembling that of the adult on a miniature scale; and these remain clinging, like the young of the female scorpion, to the parent's body for a considerable period. No such phenomenon has as yet been observed in the commercial species; and it would appear that the floating embryos settle into deep water to undergo their metamorphoses, and only make their appearance on the superficial reefs on approaching the adult state, when they are in a fitter condition to cope with the strong tides and heavy seas that circulate through and break upon these areas.

As intimately connected with the investigations prosecuted concerning the breeding phenomena of Bêche-de-mer, their rate of growth, and the habitats of the different varieties during successive stages of their existence, the question naturally arose whether regulations were necessary, or desirable, for prohibiting their collection or exposure for sale below any appointed size. From the knowledge so far available, the institution of any such regulations would appear to be premature. A careful examination of the minute epidermal spicules of all the leading varieties of Bêche-de-mer with the aid of a microscope demonstrated the fact that these differ from one another, in separate species, to an appreciable extent. It was by this means found that the fish placed upon the market, chiefly from New Guinea, as small-black fish, was not, as commonly believed, an immature ordinary-black fish, but an entirely distinct species. Subsequent inquiries elicited the fact that this variety never grows to a large size, and that it was collected on

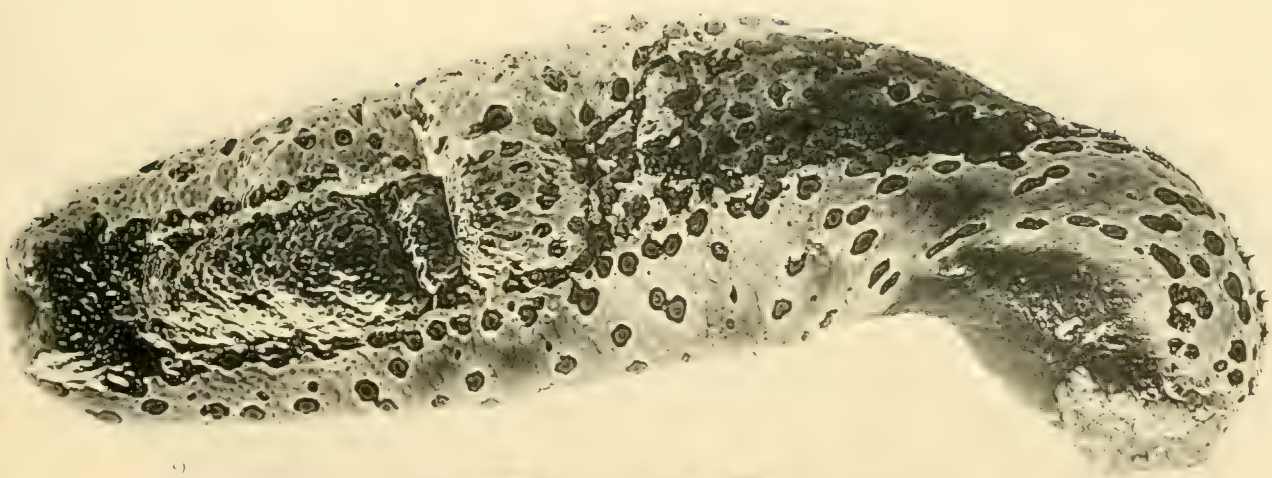
the mud flats near mangroves, and not from the clean-swept reefs affected by its typical black ally. Regulations which had been previously advocated for prohibiting the collection of this small variety of Bêche-de-mer would have been misplaced. As so far observed, the young or immature individuals of the commercial species are never collected to an extent demanding the imposition of restrictive legislation.

Respecting the bathymetrical or vertical distribution of commercial Bêche-de-mer, red, black, and prickly-fish are reported to occur at a depth of four or five fathoms, and lolly-fish have been observed by divers as deep down as eighteen fathoms. The deep-water examples of the red and black varieties, obtained by diving, are of the largest, and, as indicated in the list hereafter submitted, they fetch a higher price, and are recognised by a distinct title in the market. The question has been discussed by certain of the boat-owners whether Bêche-de-mer might be profitably collected with the aid of diving apparatus after the manner of pearl-fish, and it will probably be put to a practical test. Black-fish and sand-fish, and many non-commercial varieties of Bêche-de-mer, were taken by the author in some quantities, with the aid of a dredge, at a depth of three or four fathoms in Port Denison, off Bowen; and it would seem possible that this implement might be profitably employed in many localities for the capture of these creatures. The southernmost point at which the Bêche-de-mer fisheries have so far been systematically worked is eastward from Mackay, occupying a position of 21° south latitude. Many large-sized species, not yet turned to practical account, however, abound throughout the Australian littoral, while one of the finer commercial types, known as surf-red, has been collected by the author, on the most southern coral-reef on the Barrier system which surrounds Lady Elliot Island.

The features that distinguish the commercial from the non-commercial varieties of Bêche-de-mer are at first sight obscure. One characteristic peculiar to some of the non-commercial varieties is the habit they possess, when handled, of ejecting from the vent rope-like masses of white cottony filaments, "Cuvierian organs," which on their first emission adhere with extreme tenacity to every object with which they come in contact. In respect of this peculiarity, the names of "cotton-fish" and "cotton-spinners" have been appropriately bestowed upon this particular group of Bêche-de-mer. What renders most of the Holothuridæ, or Bêche-de-mer, family, including all the European species, useless for the market is the comparatively soft texture of their flesh, which decomposes or assumes a gelatinous condition within a few hours after their removal from the water or on being placed in the boiling-pot. They cannot be cured. It is possible, however, that if immersed in brine, or treated with some strong astringent immediately after collection, certain of these hitherto non-commercial forms might be turned to profitable account.

The quantities and value of the Bêche-de-mer that have been annually exported from Queensland within the ten years 1880 to 1889 are herewith appended. The figures will suffice to indi-

1.



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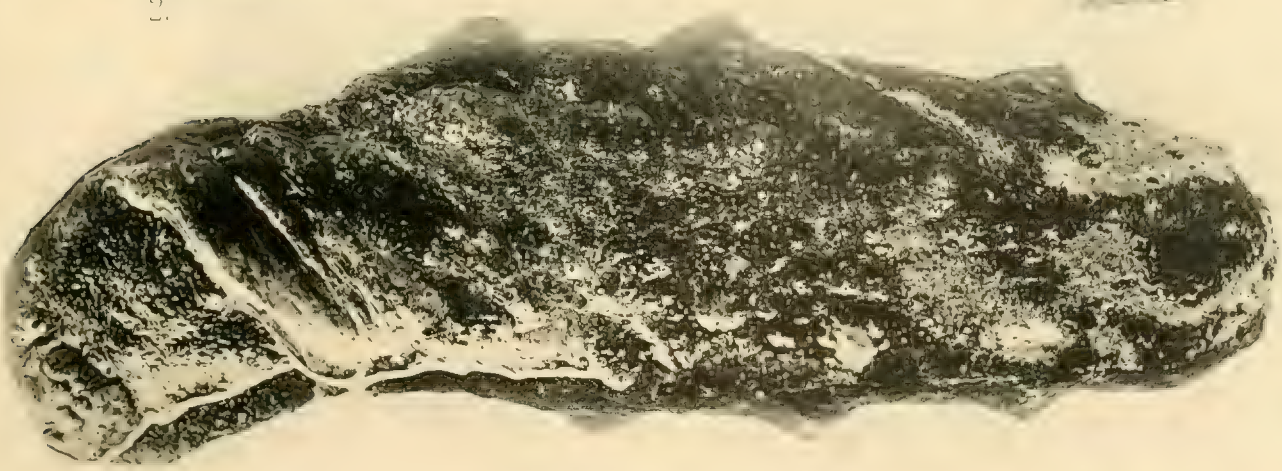

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1. BÊCHE-DE-MER. SMALL LOLLY-FISH. 2. BÊCHE-DE-MER. SPOTTED-FISH. 3. TEAT-FISH.

cate the important position this fishery occupies among the industries of the colony, and to emphasise the desirability that exists for according it every reasonable encouragement and support. It is worthy of remark that the monetary value of the total annual output closely corresponds with, but is somewhat in excess of, that of the oysters so extensively exported from the southern district of Queensland to the neighbouring colonies. China represents the market to which, with the exception of a few hundredweights, all the Australian Bêche-de-mer is consigned; in which market that shipped from Cooktown, and known as Barrier fish, enjoys a higher reputation and realises better prices than the article derives from any other locality on the face of the globe. As shown in the following schedule, "teat-fish," with a value of from £140 to £150 per ton, occupies the premier position. As much, however, as £160 per ton has been occasionally realised for exceptionally well-cured red-fish. The prices of all varieties are subject to considerable fluctuation, which is intimately associated with the current value of gold in the Chinese market.

RETURN SHOWING QUANTITIES AND VALUE OF BÊCHE-DE-MER EXPORTED FROM QUEENSLAND WITHIN THE TEN YEARS 1880 TO 1889.

Queensland.		Foreign (New Guinea, shipped from Queensland).		Total.	
Weight.	Value.	Weight.	Value.	Weight.	Value.
Cwt.	£	Cwt.	£	Cwt.	£
1880.—3,199	14,614	775	3,729	3,974	18,343
1881.—4,971	23,336	1,264	5,950	6,235	29,286
1882.—5,093	25,032	1,249	5,882	6,342	30,914
1883.—4,299	21,208	2,542	10,373	6,841	31,581
1884.—4,314	18,474	1,380	6,393	5,694	24,867
1885.—4,028	19,209	1,156	4,571	5,174	23,780
1886.—3,945	15,551	1,188	3,959	5,133	19,510
1887.—3,255	12,959	502	1,570	3,757	14,529
1888.—4,418	18,379	419	1,669	4,837	20,048
1889.—4,190	18,349	1,445	4,391	5,635	22,740

The foregoing return shows that the most flourishing epoch of the Queensland Bêche-de-mer trade was between the years 1881 and 1883, when the value of the total annual exports approximated to, or even exceeded, £30,000. The most unremunerative period was the year 1887, when the total export value fell to £15,000. Since then there has been a tendency towards improvement, which is apparently still in progress, the licenses for boats taken out for the past few years having been on an increasing ratio. The returns in this direction show that 62 boats are now licensed from Port Kennedy, in Thursday Island, and 27 from Cooktown. To these are to be added some half-dozen which have taken out licenses at Townsville, Cairns, and Ingham. This gives a total of over one hundred craft engaged in the fishery.

The current prices of the individual commercial varieties of Queensland Bêche-de-mer, as recently quoted in the Cooktown market, and supplied to the author by a prominent member of the trade, are as follows. The Chinese names, furnished by a leading Chinese merchant, are also added, and were obtained through the instrumentality of Mr. H. Birkett, the Sub-Collector of Customs at Cooktown.—

Local Name.	Chinese Name.	Value per Ton.
		£ £
Teat-fish, black and ordinary	Se-Ok-Sum	140 to 150
,, white	Ma-See-Up	40
Red-fish, ordinary and deep water	Hung-Hur	100 to 110
,, surf	Ba-Doy-Hur	80 to 90
Black-fish, deep water (also, crape black ?)	Chao-Sah-Oo	110
,, ordinary and Caledonian	Woo-Sum	80 to 90
Large Lolly-fish	Chong-Sum	35
Prickly-fish, or prickly-red	Chee-Sum	30 to 40
Sand-fish (no present demand)	(not named)	20 to 30

Up to the present date, the vast quantities of Bêche-de-mer collected in the Great Barrier Reef fishing grounds, with the exception of a very insignificant proportion, have been shipped to China, where, as previously mentioned, they occupy a forefront position with relation to the same class of material derived from all other sources. The small proportion that does not reach the Chinese market is consumed in Australia, and is yearly becoming more considerable. Bêche-de-mer soup, skilfully prepared, is regarded by many connoisseurs to be equal to turtle, and is already a favourite in the *menus* of the leading clubs and hotels in all the Australian capitals. It will doubtless eventually find its way into the European market. It offers the enterprising *chef* undreamt of possibilities, linked with such euphonious (Chinese) titles as "Se-Ok-Sum," "Woo-Sum," and "Ma-See-Up."

In addition to the nine leading varieties of Queensland Bêche-de-mer mentioned in the foregoing list that find most favour in the Chinese market, there are several supplementary species which go to swell the general bulk exported to the Flowery Land. These supplementary types of Bêche-de-mer are, however, not dealt with as distinct ones, but are utilised more often as "judicious blends" to swell the mass of the finer sorts. In this manner the Bêche-de-mer merchants may be said to reciprocate the delicate attentions paid by the Celestials, in their desire to save the European palate from becoming palled by too uniformly pure a course of unadulterated Kaisow or Moning. Among the more prominent species of Barrier Bêche-de-mer that are thus utilised as "blends," the large cream-coloured "Stone-fish," the "Sand-fish," the "Spotted" or "Leopard-fish," and the "Small Lolly-fish," are most noteworthy. The last-named two species have already (p. 56) been referred to. Of the small Lolly-fish, *Holothuria sanguinolenta*, n.sp., it may be further mentioned that in order to cure it

successfully, the precaution is taken, by experts, to slit open and eviscerate the fish before boiling. If, on the contrary, the boiling process is, as customary with the better sorts, first practised, the organism shrinks up to a mere hollow skin. A similar plan of treatment would not improbably be found efficacious for the curing of many additional species of Bêche-de-mer. Regarding the "Sand-fish," which occupies the lowest position on the commercial list, the most detrimental thing about it is the thick encrustment of minute calcareous spicules with which its integument is filled. These are so abundantly developed that it is possible to utilise the dried bodies, like chalk, for marking purposes. When mixing the Sand-fish with other more valuable types, the subterfuge is not unfrequently resorted to of dyeing their bodies a deep red-brown in a decoction of the bark of the red mangrove, *Rhizophora mucronata*. Thus treated, they are not easily detected, when mixed in bulk, from the poorer descriptions of ordinary red-fish.

Spirit-preserved specimens of all of the leading varieties of Barrier Reef Bêche-de-mer were brought to England by the author, and have been contributed by him to the British (Natural History) Museum collections. At that institution the series has been carefully worked through by Professor F. Jeffrey Bell, the specialist in charge of the Echinoderm Department, so that it is possible in these pages to publish a complete list of their scientific as well as their vernacular designations. The Bêche-de-mer contained in the collection examined and identified by Professor Bell number no fewer than fourteen distinct species. To these, several supplementary forms, either previously identified by the author, or represented by photographs or sketches in his note-books, are here added, swelling the series of edible Barrier species, and their near allies, to twenty. The list in its complete form is herewith subjoined.—

GREAT BARRIER REEF BÊCHE-DE-MER.

	Popular Name.	Technical Name.
1	Red Prickly-fish	*Stichopus variegatus*
2	Green Prickly	,, *chloronotus*
3	Yellow Prickly	,, *lutea*, n.sp.
4	Stone-fish	*Actinopyga lecanora*
5	Ordinary Red-fish	,, *obesa*
6	Surf-Red	,, *mauritiana*
7	Deep-water red	,, *echinites*
8	Black-fish	,, *polymorpha*, n.sp.
9	Black or Ordinary Teat-fish	*Holothuria mammifera*, n.sp.
10	White Teat-fish	,, *marmorata*, n.sp.
11	Grey Sand-fish	,, *fusco-cinerea*
12	White Sand-fish	,, *edulis*
13	Brown Sand-fish	,, *impatiens*

	Popular Name.	Technical Name.
14	Spotted or Leopard-fish	*Holothuria argus*
15	Large Lolly-fish	,, *vagabunda*
16	Small Lolly-fish	,, *sanguinolenta*, n.sp.
17	Black Cotton-fish	,, *atra*
18	Snake-like, or Yellow-plumed Bêche-de-mer ...	,, *coluber*
19	Yellow Cotton-fish	,, *vitiensis*
20	Corrugated Bêche-de-mer	,, *botellus*

The above list comprises four species that Professor Bell has pronounced to be new to science. These include two of the most valuable commercial varieties—*i.e.*, the so-called Black-fish and the ordinary Teat-fish—here associated with the titles of *Actinopyga polymorpha* and *Holothuria mammifera* ; these names (in anticipation of their proving to be new species) were provisionally conferred on them in a brief diagnosis of the external characters of some half-a-dozen of the leading commercial varieties included in the author's Report on the Barrier Reef Bêche-de-mer fisheries, compiled for, and published by, the Queensland Government in the year 1890.

Pending the production of a systematic catalogue of the Queensland Bêche-de-mer, a brief synopsis of the living, external, features of the species included in the foregoing list is herewith submitted. Being drawn up from notes, sketches made, and photographs of living specimens taken by the author at the various Barrier fishing stations, it may prove of practical use in the comparison and determination of species obtained from other Bêche-de-mer-producing districts of the Australian coast-line.

DESCRIPTIVE SYNOPSIS OF COMMERCIAL SPECIES OF QUEENSLAND BÊCHE-DE-MER.

Genus Stichopus.

Spicules absent or represented by simple granules ; the integument usually associated with conspicuously protruding, simple, or branched, papillæ.

No 1. Red Prickly-fish or Prickly-red, *Stichopus variegatus* (Plate XXXV.b).—Body in extension elongate subcylindrical, somewhat depressed, the entire dorsal and lateral surfaces ornamented with large aculeate conical papillæ of various patterns ; the papillæ at the two extremities for the most part simple, those of the sides usually bidentate or tridentate, and those throughout the central dorsal region presenting an irregular stellate outline ; locomotive acetabula large, forming a single continuous series throughout the ventral surface ; slender tactile suckers interspersed among and upon the stellate papillæ of the dorsal region ; ground colour, tawny-yellow ; the papillæ and ventral acetabula more usually light-red ; short irregular transverse lines

of a blackish hue distributed among the papillæ on the dorsal and lateral surfaces; and the whole of this area, including the papillæ, thickly sprinkled with minute orange specks; colour of oral tentacula light buff. Attaining to a length, when extended, of three or four feet, with a diameter of four or five inches. Usually collected, by diving, in deep water on the more remote reefs. Of considerable commercial value.

2. Green Prickly-fish, *Stichopus chloronotus* (Chromo XII., Fig. 3).—Body in extension elongate, sub-quadrate, its surface beset with prominent simple sharp-pointed conical papillæ; ground colour clear bottle-green throughout, the extreme tips of the papillæ orange or scarlet; the expanded tentacles ash-grey or a lighter tint of the body-colour. Usual length, when extended, nine to twelve inches. Occurs abundantly on the grassy (*Zostera*) flats adjoining the coral-reefs from Torres Strait to the central Barrier district. No commercial use, dissolving into a glutinous mass within a few hours after removal from the water.

3. Yellow Prickly-fish, *Stichopus lutea*, n.sp.—Body in extension elongate-ovate, slightly sub-quadrate; short, sharp-pointed, conical papillæ sparsely scattered throughout the surface of the integument, which is also slightly corrugated; colour of the upper surface of the body golden- or mustard-yellow, the papillæ usually of a blue-black hue; the under surface of the body bright yellow, the three distinct rows of pedicels slate-grey; the expanded tentacles light-brown. Length of extended body, twelve to fourteen inches. Tolerably plentiful throughout the Barrier district. Of little or no commercial value, its substance rapidly disintegrating.

Genus Actinopyga.

Integument enclosing minute calcareous spicules of definite patterns; vent pentagonal, associated with five, externally conspicuous, calcareous ossicles.

4. Stone-fish, *Actinopyga lecanora*.—Body in extension simply ovate or elongate, usually broadest anteriorly; its surface smooth; the general ground-colour cream or stone-colour, with the exception of, more usually, a few irregularly scattered patches of minute, closely approximated, dark brown speckles, certain of which are almost invariably developed in a circle round, but at a little distance from, the ventral aperture; extended tentacles and pedicels cream-colour or light brown. Length, twelve to sixteen inches. Not common. Of but little commercial value.

5. Ordinary or Sand Red-fish, *Actinopyga obesa* (Chromo XII., Figs. 1 and 2).—Body in extension elongate subcylindrical, somewhat depressed; when contracted the entire dorsal surface coarsely corrugated transversely, fine reticulating lines uniting the transverse rugæ; locomotive or ventral acetabula forming three distinct rows; slender, tactile, pedicels thickly developed throughout the dorsal surface of the body; vent pentagonal, with five distinct anal ossicles; ground colour deep golden-brown, oral tentacles somewhat lighter; under surface yellowish-brown. Length, when extended, fifteen to twenty-four inches. Habitat: Reefs exposed at spring-tides throughout the Barrier district, not concealing itself within rock crevices. One of

the most valuable commercial varieties. (This species was provisionally associated by the author, in his Queensland Government Report, with the name of *Holothuria rugosa*).

6. Surf Red-fish, *Actinopyga mauritiana*.—Body elongate-ovate subcylindrical, not distinctly corrugated; ground colour red-brown, with conspicuous white patches of various size and number, interspersed with smaller spots and speckles of the same hue, usually developed along each side, and forming a circum-anal patch; smaller white specklings often developed on the dorsal surface, but scarcely two individuals marked alike; under surface brick-red. Length twelve to fifteen inches. Abundant among the surf on the outer edge of the reefs in the central Barrier district. Of high commercial value.

7. Deep-water Red-fish, *Actinopyga echinites*.—Closely resembling ordinary Red-fish, but having a smoother integument, and inhabiting deep water. A critical examination of living examples of this species has not been made by the author, a single specimen only having been taken with the dredge in Port Denison, and immediately transferred to spirit. Of high commercial value.

8. Ordinary Black-fish, *Actinopyga polymorpha*, n.sp. (Chromo XII., Fig. 6).—Body highly plastic or polymorphic, varying in extension from elongate subcylindrical to an obtusely ovate or nearly globular shape; skin smooth in both extension and contraction; locomotive acetabula disposed in three distinct rows; slender tactile suckers developed throughout the surface of the body; vent pentagonal with five conspicuous red-brown anal ossicles; general ground colour of the body, dark seal-brown, or nearly black; oral tentacles tufted, slightly lighter in colour. Average length, in extension, twelve to fifteen inches. Habitat: Reefs exposed at spring-tides, usually secreting itself in fissures of the coral-rocks and creeping out with the rising tide. Of high commercial value.

Genus Holothuria.

Integument spiculiferous; vent circular, devoid of conspicuous calcareous ossicles.

9. Black or ordinary Teat-fish, *Holothuria mammifera*, n.sp. (Plate XXXIV., Fig. 3).—Body in extension elongate, somewhat flattened, obtusely rounded at each extremity, with usually from four to six large, conical protuberances developed at even intervals along each lateral border. Surface of the skin smooth in extension and contraction; locomotive suckers of the ventral region forming three distinct rows anteriorly, merging with one another posteriorly; small isolated tactile suckers developed throughout the dorsal surface; vent circular, devoid of ossicles; general ground colour of the body, dark grey to black, often irregularly mottled; oral tentacles tufted, light slate-grey; ventral acetabular disks, whitish. Average length when extended, twelve to eighteen inches. Habitat: Usually obtained from deep water on the reefs. The most valuable of the Great Barrier commercial species.

10. White Teat-fish, *Holothuria marmorata*, n.sp.—Body in extension elongate, somewhat depressed, pointed posteriorly, with about six, somewhat acutely-pointed, conical protuberances

on each side; tactile suckers abundant throughout the dorsal region; colour, cream, or light stone-colour, with golden-brown patches or mottlings of various shapes and dimensions, throughout the dorsal and lateral surfaces, no two individuals being marked precisely alike; tactile suckers and tentacles, light brown; length eight to twelve inches; not abundant. Of small commercial value.

11. Grey-fish, or Grey Sand-fish, *Holothuria fusco-cinerea.*—Body elongate-ovate or subcylindrical, somewhat depressed, very slightly flexible, corrugated transversely when contracted; locomotive acetabula sparsely and irregularly scattered along the ventral surface; slender tactile papillæ similarly developed on the dorsal aspect; vent funicular, subcylindrical, its free edge fimbriate; colour varying from light to dark ashen-grey, the ventral region of similar colour, or only slightly lighter, short irregular transverse blackish bands, to the number of ten or twelve, commonly present on the dorsal surface; oral tentacles light grey or buff. Length in extension ten to fifteen inches. Habitat: Common on sandy shores and reefs exposed by the ordinary tides. Of little commercial value, owing to the abundance of spicules developed in the integument, which impart to it, when cured, a distinctly chalky aspect and consistence.

12. White-fish, or White Sand-fish, *Holothuria edulis.*—Closely resembling the last species, but with a simple, non-funicular, ventral aperture, and nearly pure white beneath. Of small commercial value, owing to the abundance of spicular elements.

13. Brown Sand-fish, *Holothuria impatiens.*—Closely resembling *Holothuria edulis*, but of a light brown hue throughout. Of small commercial value.

14. Spotted or Leopard-fish, *Holothuria argus* (Chromo XII., Fig. 7).—Body in extension elongate-ovate, rounded at each extremity, its surface smooth; ground colour, lilac, diversified with oval or rounded golden-brown spots which are usually partly disposed in longitudinal chain-like series, and partly irregularly scattered throughout the dorsal and lateral surfaces, no two individuals being precisely alike in this respect; each golden-brown spot contains a centrally-located, dark brown, tactile acetabulum, and its circumference is defined by an inner dark brown and an outer pure white line; oral tentacles light brown. Length twelve to eighteen inches. Emits cotton-like, Cuvierian filaments very plentifully. Abundant on the reefs at ordinary low tides. Of little commercial value, but sometimes mixed with the better kinds.

15. Large Lolly-fish, *Holothuria vagabunda.*—Body in extension elongate cylindrical, its surface conspicuously corrugated. Intense velvety black throughout, with the exception of a thin red or orange line around the aperture of the vent; oral tentacles and ventral and tactile pedicels, black; the terminal acetabula of the latter grey. Abundant on the outlying reefs of the Barrier system. Of low commercial value.

16. Small Lolly-fish, *Holothuria sanguinolenta*, n.sp. (Plate XXXIV., No. 1).—Body in extension elongate subcylindrical, tapering towards each extremity, highly flexible; locomotive acetabula

forming a single series; slender tactile papillæ developed abundantly throughout the dorsal aspect; vent cylindrical, devoid of anal ossicles; colour, purple black; a dark red fluid exuding from the surface of the skin when the animal is handled roughly; oral tentacles and ventral acetabula, black. Length when extended, twelve to eighteen inches. Habitat: Common on the outlying reefs of the Great Barrier system. Of but little commercial value. The muscular and connective tissues of this species are of much less firm consistence than those of the black, red, or teat varieties, and when cured the individual bodies are comparatively hollow and of light weight.

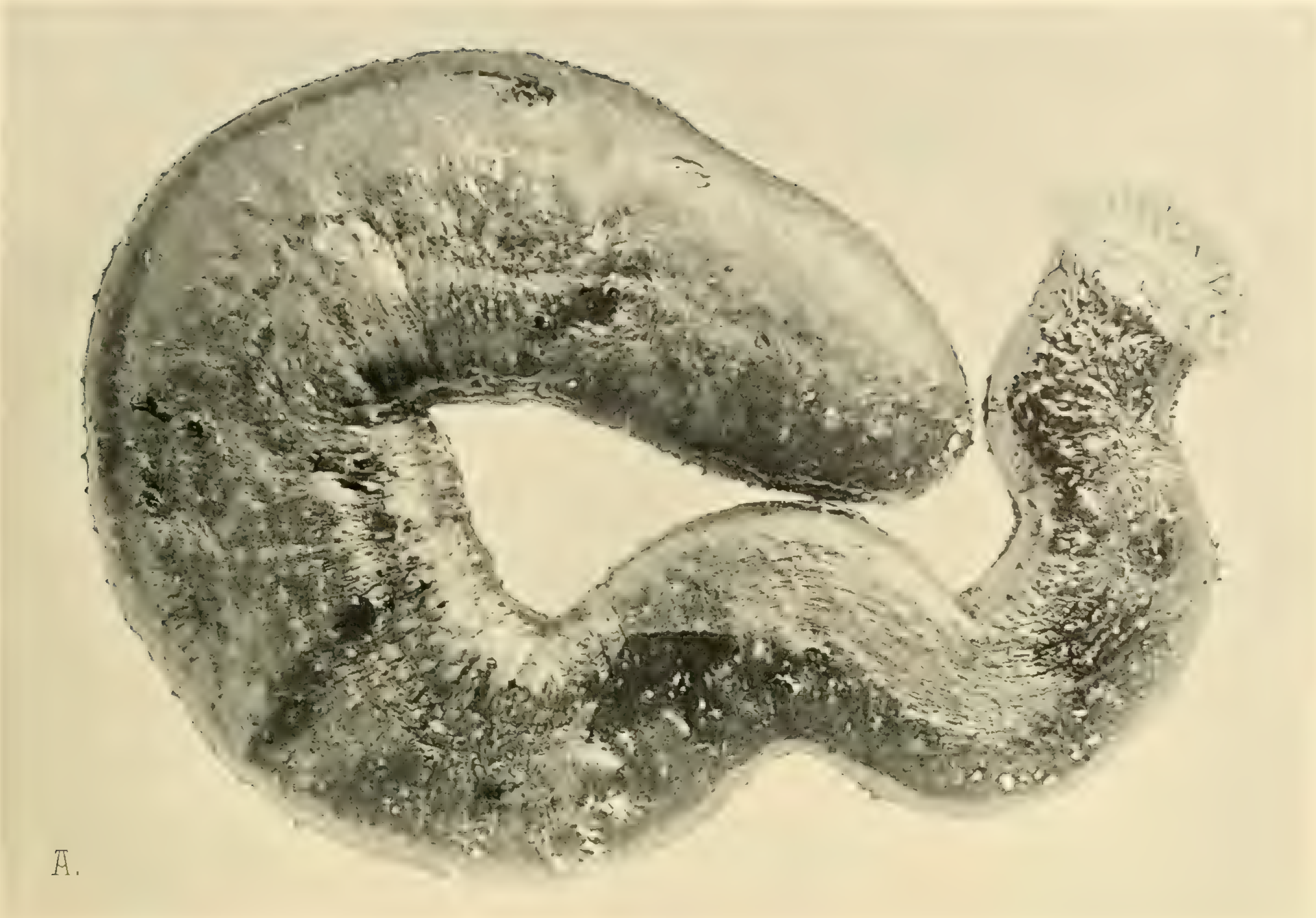
17. Black Cotton-fish, *Holothuria atra* (Plate XXXIII.B).—Body in extension elongate cylindrical, most slender anteriorly; profusely papillose throughout, through the presence of the thickly-developed, slightly protruding bases of the acetabula; oral tentacles and ventral acetabula dark brown or black. Length fifteen to eighteen inches. Emitting large quantities of cotton-like Cuvierian filaments. Common on all inshore reefs; usually, when extended, having a portion of the hinder region of its body retained within a crevice of the reef. Of no commercial value.

18. Snake-like or Yellow-plumed Bêche-de-mer, *Holothuria coluber* (Plate XXXV.A and Chromo XII., Fig. 5).—Body in extension elongate cylindrical, tapering anteriorly; closely resembling that of the last species, but the surface of the integument harsher, somewhat coriaceous; general ground colour purple-black, ventral pedicels and points of tactile acetabula orange or yellow, the oral tentacula primrose-yellow. Length eighteen to twenty inches, not emitting cottony Cuvierian filaments. Common on inshore reefs in company with *H. atra*, but more often crawling freely on the surface of the reef. Of little or no commercial value.

19. Yellow Cotton-fish, *Holothuria vitiensis*.—Body in extension elongate-ovate, depressed, its surface smooth; aperture of the vent distinctly stellate; ground colour throughout tawny-yellow; the oral tentacles and tactile acetabula grey-brown. Length ten to fourteen inches. Emitting vast masses of tenacious, cotton-like Cuvierian filaments, abundant on the level surfaces of the reefs, and among the grassy (*Zostera*) flats. Of no commercial use.

20. Corrugated Bêche-de-mer, *Holothuria botellus*.—Body in extension elongate subcylindrical, tapering anteriorly; thickly beset with wart-like elevations that represent the bases of the tactile acetabula; colour of the general surface of the body grey, that of the wart-like papillæ light yellow; oral tentacles, ventral pedicels, and tactile acetabula light yellow. Not emitting Cuvierian filaments. Common under rocks or coral boulders on the foreshore reefs. Of no commercial utility.

The descriptions of Bêche-de-mer included in the foregoing list and diagnostic synopses comprise all the commercially valuable species of the Great Barrier district, and also the conspicuously large varieties, which are liable to be mistaken by "new-chum" explorers for commercial species. In addition to these there are a considerable number of Holothuriæ of smaller size or possessing features which render them easily distinguishable from the edible



A.

B.

W. Saville-Kent, Photo.

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A. SNAKE-LIKE BÊCHE-DE-MER. B. PRICKLY-FISH.

types. A few of these will receive attention in subsequent pages, as there are one or two points of more immediate interest concerning the commercial forms and their near allies. It is worthy of note, among other matters, that the form described under the title of Red Prickly-fish, *Stichopus variegatus*, some ten years ago realised the highest market price, selling for as much as from £130 to £150 per ton. Its present low position on the list (£30 to £40 per ton only) is due to the fact that a consignment of this variety was sent to China that had been boiled, previously to curing, without any suspicion of danger, in a copper boiler, the result being that a number of Chinese were poisoned. Poisonous properties were immediately attributed to this particular species of Bêche-de-mer, and for a time its sale was altogether interdicted. It is only now slowly recovering its position in the market. The accuracy of this explanation of the depreciated value of Red Prickly-fish has been vouched for to the author by the station-owner who unwittingly cured and despatched the fatal consignment. Through the same informant the author has been made aware of the exceedingly acrid properties of the essential juices of Bêche-de-mer, which, if collected and left in bulk for any time in a copper-riveted boat, eats like an acid into, and destroys, the metal.

In a work entitled *Coral Lands* by H. Stonehewer Cooper, it is stated (p. 266) that the cottony filaments, or Cuvierian organs, exuded in quantity by Polynesian species apparently allied to, if not identical with, *Holothuria argus*, produce a painful inflammation on any part of the human skin with which they may come in contact; also, that the water and associated juices ejected abundantly from other species, when handled, possesses highly inflammatory properties, causing, if it should fall on a surface abrasion of the skin, intense pain, or, if it should come in contact with the eyes, possible loss of sight. No such deleterious properties are associated with the Barrier Reef species, all of which have been handled with impunity, and with, more frequently than otherwise, abraded hands, by the author; nor has the slightest hint of such an undesirable quality been brought under the author's notice, for, if existing, it would have undoubtedly come in the course of his investigations. Mr. Cooper writes only of four kinds belonging to the Polynesian region, the three others being evidently nearly related to the ordinary teat and black and red varieties. As is well-known, fish which are good eating in one region may be poisonous in others, and the same principle may hold good with reference to allied, if not identical, species of Bêche-de-mer.

The remarkable phenomenon of the ejection of the "Cuvierian" filaments in many of the species of Bêche-de-mer is a subject which has attracted a considerable amount of attention, but has not yet been fully explained. In such a form as the yellow Cotton-fish, *Holothuria vitiensis*, these filaments are poured forth, on handling the animal, in copious streams, resembling snow-white hanks of darning-cotton, that appear to be almost inexhaustible. There is a European species, *Holothuria nigra*, occurring on the Cornish coast and locally known as the "Cotton Spinner," that ejects its Cuvierian organs in the same manner, though to a less conspicuous extent. Mr.

E. A. Minchin, who has recently investigated the phenomenon as exhibited by this species—(*Annals and Magazine of Natural History*, October, 1892, p. 273)—has found that the organs normally attached to the external wall of the intestine when first discharged pierce the walls of the cloaca, and are then shot out through the rectum after the manner of a rocket. Each individual organ or filament, when first released, possesses an inflated head, which becomes gradually diminished in size as the thread elongates, and until it reaches, so to say, the extreme length of its tether. The actual or determining cause of the lengthening process remains, as yet, undiscovered—an inherent automatic power of elongation—the unreeling of an enclosed spiral thread—the action of water pressure forced in from the cloaca,—have been respectively advocated by authorities as furnishing a probably correct interpretation. Having regard to the extreme tenacity and plasticity of the Cuvierian filaments, and their development in many of the Great Barrier species in such copious masses, the suggestion arises whether the substance could not be turned to economic use as a substitute for caoutchouc. Its tenacious, glue-like consistence, when first extended, and its flexible and elastic properties when subsequently dried, appear to lend some support to the anticipation of latent possibilities in this direction.

In the coloured plate, Chromo XII., illustrating various representatives of the Bêche-de-mer tribe, there are one or two figures which would appear at first sight to possess no legitimate claim for admission among this class of organisms. The first of these, Fig 3A, is a species of flat, large-scaled worm, closely allied to the familiar *Polynoe setosa* of European seas; but, in place of lurking under stones on the seashore, as does that species, this form is invariably associated with the bottle-green-tinted Bêche-de-mer, *Stichopus chloronotus*, figured immediately beneath it. Clinging closely to the integument of the Holothurian, in the interspaces betwixt the projecting papillæ, it can, in life, be scarcely detected, the colours in the two animals perfectly harmonising. By way of comparison with the ordinary representatives of the genus Polynoe, the parapodial appendages of this commensal type are specially modified to the form suckers which enable it to cling to its elected host. A corresponding commensal annelid has been found by the author associated with the species of Bêche-de-mer, *Actinopyga mauritiana*, previously described under the title of Surf-red. In this instance it has also adapted itself to the colour of its host, being of a clear red-brown hue. There are some species of Bêche-de-mer that entertain guests on much more intimate terms than those of mere outside "hangers-on," such as are these annelids. The fish, for example (a species of Fierasfer), delineated in Fig. 10 of Chromo XII. —inhabits the body cavity of the large teat-fish, *Holothuria mammifera*, in the same manner as the two species of Amphiprion (figured in Chromos I. and II.) lodge with their associated anemones. Among the Bêche-de-mer fishers, these commensal fish are popularly known by the name of "Glass Eels." So far as the author has been able to ascertain, the above-named species of Holothuria is the only one among the many known varieties that shelters a Fierasfer.

On the pearl-shelling grounds of Western Australia, a fish of the same genus lodges within the mantle-folds of the large mother-of-pearl shell, *Meleagrina margaritifera.* An interesting example is exhibited in the shell gallery of the British (Natural History) Museum, in which a Fierasfer, having apparently died in this position, has been enclosed by the mollusc within a pearly sarcophagus.

Figures 8 and 9 of the Chromotype plate No. XII., delineate organisms that do not precisely coincide in aspect and structure with the typical Bêche-de-mer, most abundantly represented in this plate. These are technically known as Synaptæ, and belong to a generic group, whose members, while allied to the ordinary Holothuriæ, differ from them in the composition of their oral tentacles. These organs are fewer in number (ten only) and pinnate, like the fronds of a fern, while the animals themselves are altogether devoid of the characteristic locomotor tubules and acetabula so conspicuously associated with the more familiar forms. In lieu of these, the surfaces of the integument of the Synaptæ are roughened by the presence of countless myriads of minute calcareous spicules, often wonderfully like anchors in shape, by means of which these animals hook on to, and literally "warp" themselves over, the surface of the ground they elect to traverse. There is one allied genus, Chirodota (more abundantly represented, however, on the South Australian coast-line), which presents the remarkable phenomenon of an animal beset, as it were, by wheels, the armature in that type being represented by the most exquisitely-fashioned, six-rayed, wheel-like spicules. The species of Synapta, *S. Beselii,* depicted in Fig. 8 of the Chromo-plate XII., is the largest known member of its tribe, not unfrequently stretching out on the reef-flats covered with the Zostera-like grass, *Posidonia australis,* to a length of five or six feet. It is also remarkable for the symmetrically nodular, quadrangular, pattern of the plications of its integument shown in the figure. Under the condition of fullest extension, however, these nodular rugæ may become entirely, or locally, obliterated, reappearing again when the animal contracts into its normal condition of repose. Its skin, in common with that of other members of the genus, is excessively thin and semi-transparent, almost permitting a vision of the enclosed viscera. This handsome species, was found most abundantly on the extensive Warrior Island reefs in the north of Torres Strait, and also, more sparingly, as far south as Rocky Island, off Cape Flattery. Different individuals, as with many of the ordinary Holothuriæ, vary considerably in their colour-patterns, some being brighter, others darker, or more variegated than the example figured.

A characteristic illustration of the colour variation to which the members of this group are subject, is afforded by the cluster of a smaller, smooth-skinned species of Synapta (Fig. 9), delineated to the right of *S. Beselii* (Fig. 8). No two of these individuals are alike, being either self-coloured, striped or diversely speckled. All five, with other additional specimens, were brought up by the dredge, in a tangled mass, in Cleveland Bay, off Townsville. A more typical, brilliantly-tinted species of Holothuria, *Colochirus anceps,* is represented by Fig. 4 of this same plate. This

gaily-decorated, bright yellow and rose-coloured type, was dredged from a depth of six or seven fathoms, in the centre of the most prolific pearl-shelling ground at the Western end of Torres Strait. The tentacles in this form differ essentially from those of the typical reef-feeding varieties. In the latter they are mop-like, and specially adapted for sweeping food particles off the rock or mud-surfaces on which the animals feed. In Colochirus, as in the British genera Psolus and Cucumaria, the tentacles are subdivided into minute filamentous ramifications, and are utilised more after the manner of a set-net, to intercept floating organisms in the surrounding water. In both instances, and also in Synapta, the process of food ingestion is identical, the pabulum being transported to the gullet by the complete inversion of the food-laden tentacles, in consecutive and almost rhythmical succession.

CHAPTER VII.

OYSTERS AND OYSTER FISHERIES OF QUEENSLAND.

WITH relation to their annual export value, the Oyster Fisheries of Queensland occupy the third position upon the list of the leading fishery industries of the colony. That of pearl-shell takes the lead with an average yearly export value of £70,000. The Bêche-de-mer yields in a like manner an average of £23,000, while the oyster fisheries for the past ten years have not exceeded an average of £8,000. The exceptionally high return of £13,068 was, however, obtained in the year 1889, when owing to disastrous floods which temporarily devastated extensive areas of the oyster grounds of New South Wales, and in a less degree those of this colony, the prices realised for the oysters exported were enormously enhanced. To the figures above quoted, as indicating the annual export value of the Queensland Oyster Fisheries, almost one-half as much again may be added, on account of the home consumption of the bivalve, thus bringing the value of the total annual average output of the fishery to some £12,000.

Though occupying a considerably lower position in the scale of actual annual value than the pearl-shell and Bêche-de-mer fisheries, the revenue accruing to the Government from the oyster fisheries,—in association more particularly with the excellently-organised system of leasing and licensing sections, banks, and grounds, as private fisheries,—is very considerably in excess of that hitherto derived from the first two-named industries, being represented by an average net revenue of close upon £4,500. As a result of the Act recently passed, which provides facilities for the establishment of corresponding private pearl-shell and Bêche-de-mer fisheries, a closer approximation of the respective revenues may undoubtedly be hereafter anticipated.

EDIBLE AND COMMERCIAL OYSTER SPECIES AND VARIETIES.

There is but one specific form of Queensland oyster that as yet receives serious consideration from a purely commercial standpoint. This oyster is the species commonly sold in the adjacent colonies under the title of the Queensland "rock oyster," the technical name of which is *Ostrea*

glomerata. Apart from this form, which, as hereafter shown, embraces a number of varieties, there are several specific types of oysters indigenous to Queensland waters, which, while neither at present so easily accessible, nor possessing other minor disqualifications, are wholesome eating; they will doubtless in future years be utilised more or less extensively for both home consumption and the export trade. In the former connection, as a matter of fact, certain of these supplementary species have already begun to command a market.

Although both the natural and the artificially-cultivated banks and beds of the leading commercial oyster are mainly associated with the extensive areas of Moreton and Wide Bay, in the southern districts of the colony, one and all of the specific forms hereafter enumerated, are denizens of the tropical waters of the eastern coast-line, and consequently fall legitimately within the category of the "Products" of the Great Barrier district. *Ostrea glomerata* occurs, in fact, in a cultivable form in close proximity to the central and northern townships of Rockhampton, Cairns, and Cooktown; while the headquarters of the majority of the other species referred to are the coral, or rocky, islets, of the Great Barrier system.

The largest edible form of oyster found in Queensland waters is distinguished by the title of the cockscomb oyster, *Ostrea cristi-galli,* so called from the regular zigzag undulations of the outer edge of its interlocking valves having some resemblance to a cockscomb. An illustration of this species will be found at Chromo plate XIV., Fig. 5. A pair of the ponderous shells of this oyster not unfrequently weigh as much as from 5 to 7 lb., and have a diameter of from eight to twelve inches. The species is an essentially salt-water form, and limited in its distribution to the tropics. It grows plentifully among the coral-reefs of Torres Strait and the Great Barrier system, in either an entirely submerged condition, or, where exposed to atmospheric influences, at ordinary spring tides. Under these last-named conditions, it has been observed by the author in especial abundance on the fringing coral-reefs surrounding what are known as M and N Islands, belonging to the Northumberland group, eastward of Mackay. This oyster is also to be seen in some quantities *in situ,* but no longer alive, on the dead, and apparently raised, coral-reef on the west side of Magnetic Island, facing Townsville. As an edible variety, the coxcomb oyster is somewhat large and coarse, and is consequently most appreciated in a cooked condition. A smaller species of cockscomb oyster is not unfrequently obtained from deeper water in Torres Strait, attached to the branches of the black coral, *Antipathes,* and other zoophytes. It is remarkable for its production of finger-like projections from the back of the attached valve. With the aid of these projections it retains a secure grasp on its chosen fulcrum, though at the same time its hold may be so loose that the shell may be slipped to and fro on its supporting base. This variety of oyster would appear to be identical with the *Ostrea folium* of Linnæus, originally recorded from the Indian Ocean.

The second largest species of edible Queensland oyster is also an essentially marine type, and limited in its distribution to the tropical districts. It varies considerably in form, and may be either simply ovate with a broader distal margin, or boat-shaped with pointed ends, as shown

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NATIVES OF WARRIOR ISLAND, TORRES STRAIT, PREPARING BÊCHE-DE-MER FOR THE CHINESE MARKET.

in Fig. 7 of Chromo plate XIV., illustrative of the oyster series. The larger individual shells of this tropical species not unfrequently measure as much as six or seven inches in their longest diameter. Their edges, in contradistinction to those of the preceding species, are usually perfectly even, or only slightly indented. A notable feature of this oyster is the very hard vitreous texture of its shell. Its colour externally is usually a light slate-grey, while internally it is pure white with a conspicuous broad black marginal border. In association with this last-named feature it has received the name of the Black-edged oyster, *Ostrea nigro-marginata*. While by no means an unpalatable oyster in the raw condition, like the preceding species, it finds greater favour stewed or scalloped. The Black-edged oyster flourishes side by side with the form next to be noticed (*Ostrea mordax*) throughout the reefs and islands of the Great Barrier system, and it is particularly large and abundant on the rocky foreshores of Adolphus and other islands in the vicinity of the Albany Pass, Torres Strait, whence it is extensively obtained as a seasonable delicacy for the settlement at Somerset. The hardness of the shells of this species, and the difficulty of detaching them from the rocks without fracture, even with the aid of hammer and cold chisel, have hitherto proved somewhat of a bar to its utilisation for commercial purposes in the ordinary manner. Within the past two years, however, this black-edged oyster has been discovered in large quantities in the vicinity of the Flinders Islands, immediately north of Cape Melville, and from this locality it has been systematically collected and distributed to Thursday Island, and to the populous districts of Normanton and Croydon, accessible from the Gulf of Carpentaria. By laying the oysters for a while, in bulk, on suitable foreshore areas, they recover from any injuries received in the process of detachment; if fatally wounded, their bodies speedily decompose and are washed out from the shells, leaving all the sound oysters in condition prime for transport. The foundation of a new industry has in consequence been laid in association with the commercial utilisation of this oyster, that is capable of indefinite extension. A conception of the possibilities associated with the cultivation of this species may be arrived at from the circumstance that the first consignments transported to the inland mining centre of Croydon readily obtained a retail price of 2s. 6d. per dozen, as compared with 6d. per dozen, the price usually paid for *Ostrea glomerata* in the Brisbane market. In testimony to the substantial dimensions which this oyster attains, it may be mentioned that the hollow shell, illustrated by Chromo plate XIV., Fig. 7, was found to possess a holding capacity of four fluid ounces, or the equivalent in weight of one-quarter of a pound of "oyster meat."

The third species of edible oyster, other than the ordinary commercial variety indigenous to Queensland, is the so-called *Ostrea mordax*, of Gould. Its area of distribution is a much wider one than that of the two preceding types, as it is found abundantly throughout the whole length of the Queensland coast-line, from the Gulf of Carpentaria and Cape York in the extreme north, to the New South Wales boundary at the Tweed Heads. It has also been recorded from Fiji, Samoa, and other island groups in the Pacific Ocean.

While enjoying so extensive an area of distribution, *Ostrea mordax* may be said to attain to its finest or maximum development among tho coral-reefs and islets of the tropical coast-line of eastern Australia; and from its remarkable abundance in this region it may be appropriately, as it is hereafter, distinguished by the suggestive popular title of the Coral-Rock Oyster. In contradistinction to the ordinary rock oyster of commerce, this coral-rock species is an essentially marine type, attaining to its most luxuriant growth among the reefs and islets of the Great Barrier system, far remote from fresh-water influences, and rarely overstepping the boundary limit of pure salt-water in its area of distribution along the rocky headlands on the mainland seaboard. In this latter situation it not unfrequently grows as abundantly as, and under conditions closely simulating those associated with, the rock variety of *Ostrea glomerata.* The zone of growth most affected by *Ostrea mordax* on either the natural rocks, conglomerate reefs, or stranded coral boulders, is coincident with that of half-tide mark; and the author has not, so far, either by practical investigation or inquiry, obtained information concerning any instance in which this oyster has been found growing beneath, or even at as low a level as, ordinary low-tide mark.

The characteristic features of *Ostrea mordax*, in its most typical form, are its normally elongate-triangular contour, the very evenly lobate edges of the interlocking shells, and the opaque purplish-pink hue of their external surface. Another peculiarity of this species, as compared with the ordinary commercial oyster, *O. glomerata*, which it often closely resembles in size and shape, is the circumstance that it is almost always affixed to its rocky support by its left valve, while the last-named form is as invariably affixed by its right one. The flattened, freely movable, so-called opercular valve, is, in a corresponding manner, developed on the right side in *Ostrea mordax*, and on the left one in *O. glomerata.* An additional point of distinction between the shells of these two species is furnished by the circumstance that the scar or impression of attachment of the large adductor muscle is in *O. mordax* set very much farther back, or towards the distal or growing edges of the shells, than in *O. glomerata;* this scar, moreover, in the upper or "opercular" valve is more usually of a deep-black hue, while in the last-named species, though occasionally of a darker tint than the surrounding nacre, it is more often colourless.

While the shape above described represents the most typical form of *Ostrea mordax*, it is subject to almost as considerable a latitude of variation as the ordinary commercial oyster, *O. glomerata.* This is due to the creature's efforts to adapt its shape to that of its environment, and the shells in consequence vary, from an almost circular to an abnormally elongate contour. A yet more conspicuous modification of this very variable species is one in which the hinge or butt-end of the attached valve is produced into a long hollow beak, which is found, on opening the oyster, to contain a very considerable amount of "meat." This beaked variety would appear to be identical with the form upon which the specific title of *Ostrea cucullata* was originally conferred; and illustrations of both it and the normal form of *Ostrea mordax*, are given in Figs. 1 and 2 of Chromo plate No. XIV. One characteristic peculiarity of the species under notice,

which, notwithstanding its excellent edible qualities, has (as in the case of the preceding type) hitherto prevented it from occupying a prominent place in the Australian markets beside the more familiar commercial varieties, is the tenacity and extensiveness of its base of attachment to its rock support, which is almost invariably coincident with the entire external superficies of the adherent shell. As a necessary consequence, much labour is requisite to separate the oysters from their attachments; and in the operation they are so liable to injury that, if packed at once in bulk and transported to long distances, a large percentage die, and engender a rapid mortality among the survivors. The species is, nevertheless, brought into some of the coast towns, such as Rockhampton and Gladstone, and there realises a price corresponding with that of the ordinary commercial form. Treated in the manner previously described for *Ostrea nigro-marginata* (viz., laid down for awhile to recover condition), it would prove equally eligible for further transport. It is a question, however, whether this *Ostrea mordax* might not be turned to more profitable account by its collection and conservation, either by tinning or otherwise, at temporarily-established stations in the immediate vicinity of its most abundant development.

In dimensions, the coral-rock oyster rarely exceeds a length of three inches, and the lower or concave shells in the finest examples examined possessed a holding capacity of one and a-half fluid ounces. The reproductive phenomena of the species have been found by the author to be essentially identical with those hereafter described for the ordinary commercial species, *Ostrea glomerata*, there being no incubation of the brood within the mantle cavity, as in the European, and the more southern Australian so-called mud-oyster, *Ostrea edulis*.

The author's attention was first directed by Captain Sykes, the harbour-master of Rockhampton, to an exceedingly remarkable variety of oyster, which in some respects resembles *Ostrea mordax*, and occurs on Rocky Island, off Keppel Bay. It is illustrated by Figs. 3 and 4 of Chromo plate XIV. In this creature the hollow, beak-like, prolongation, or umbo, of the attached shell, alluded to in connection with the variety cucullata, and depicted in Fig. 2 of the same plate, is so abnormally developed that the movable, or opercular, valve, presents the aspect of a small hinged lid set upon the summit of an elongate, corrugated tube. In the upper of the two examples figured, the relative dimensions of the two shells are so disproportionate that while the right, or opercular, one measures just over an inch in diameter, the left or attached one measures, from its free edge to its base, no less than six inches. This extraordinary modification is apparently brought about through the oysters being crowded close together on the sides of perpendicular rocks, with no room for lateral expansion, growth being, in consequence, centred in the vertical elongation of the attached valve. As shown by making rough sections, the cavity occupied by the living oyster, in this species, extends through the anterior third only of the entire shell, the remaining or basal two-thirds, consisting of consecutive chambers bounded by cellular laminæ that represent its successive growth-lines.

With respect to the shape and proportions of its component shells, this tubular oyster bears

a remarkable resemblance to a fossil group of bivalve mollusca known as the Hippuritidæ, which are peculiarly characteristic of the cretaceous deposits. This resemblance is, however, superficial, for it relates only to the corresponding disparity in the respective dimensions of the right and left valves, and in the modification of the unattached valve in such manner that it presents the form of a relatively small movable operculum. While all oysters (genus Ostrea) belong to that special group, the Monomyaria, whose shells are united by a single adductor muscle, the Hippurites belonged undoubtedly to that distinct section, the Dimyaria, including mussels, cockles, and the majority of bivalves, in which two adductor muscles are invariably present. It is worthy of note, however, in this connection, that, as recently shown by Dr. R. T. Jackson, in his admirable thesis on the "Phylogeny of the Pelecypoda" (*Memoirs Boston Soc. Nat. Hist.*, 1890), the American oyster (*Ostrea virginiana*) at any rate passes through an intermediate embryonic condition when it possesses two distinct adductor muscles, while it has also a yet earlier developmental phase, in which only one such muscle is represented. The significance of these developmental facts is, that the oyster is in all probability the descendant of an ancestor corresponding with the Hippurites in the possession of two adductor muscles, and that the Hippurites and all allied Dimyarian types are in like manner the phylogenetic offspring of a primitive Monomyarian ancestor.

In the account of the Hippuritidæ contained in Woodward's "Manual of the Mollusca," the portion of an oyster closely resembling the type here introduced, is figured, under the title of *Ostrea cornucopiæ*, a species originally established by Lamarck. The original figures of Lamarck's type, however, given in the illustrated edition of the "Encyclopedia Methodique," published in the year 1827, represent a rostrate oyster, more nearly resembling a form, *O. mordax*, illustrated by Fig. 2 of Chromo plate XIV., which is identified by the author with the *Ostrea cucullata* of Born. In a footnote to the latest edition of Lamarck's "Animaux sans Vertebres," Vol. VII., p. 230, 1836, the editors maintain that *Ostrea cornucopiæ* and *O. cucullata*, as represented by the Paris Museum types, are varieties only of one and the same species. In the same manner that the beaked *O. cucullata* has been shown to represent a variety only of the ordinary *Ostrea mordax*, the very elongated tubular form here figured and described, is regarded by the author as representing an exaggerated growth of the variety cucullata. From an examination of a very considerable number of specimens of all ages, derived from different localities, it has been found possible to arrange an unbroken series from the typical *Ostrea mordax* through the beaked variety, culcullata, to the elongate tubular form. Under these circumstances it is desirable to associate it only with a title that shall indicate its position as a remarkable variety of *Ostrea mordax*, and in that association I here confer upon it the distinctive name of *O. mordax*, variety *cornucopiæformis*. Many other oysters, it may be remarked, exhibit the same tendency of the attached valve to become abnormally elongated and camerated. Examples in the teaching collection of the Royal College of

Science, submitted to the author by Professor G. B. Howes, associated with the title of *Ostrea cornucopiæ*, represent, apparently, abnormal growths of *Ostrea edulis*, while the more normally elongate American species, *Ostrea virginiana*, produces numberless "sports" in a corresponding direction.

Among other subsidiary characters, which may be cited, as indicative of the close relationship of the variety cornucopiæformis to the ordinary *Ostrea mordax*, is that of a similar peculiarly opaque purplish-pink tint of the external surface of the shells, with which is combined a corresponding striate sculpturing of microscopic fineness. The scar-like marking on the opercular valve, due to the attachment of the adductor muscle, is also invariably of a black hue. The associated clusters of this remarkable oyster, when viewed superficially, with little beside the opercular shells visible, can in no way be distinguished from the ordinary growth of *Ostrea mordax*; and it is only on breaking them asunder and exposing the abnormally elongated lower valves that their distinctness becomes apparent. The aspect and flavour of the "meat" of this oyster also correspond with that of the ordinary mordax; and of it, from within the deeply-excavated lower valve, a much larger morsel is to be extracted than outward appearances at first sight suggest. The localities on the Queensland coast, in addition to the vicinity of Keppel Bay, where this variety cornucopiæformis may be found, include the neighbourhood of Sweer's Island in the Gulf of Carpentaria; and animals modified in the same direction, but to a lesser degree, have been collected by the author near the Bay Rock Lighthouse in the vicinity of Townsville, and at Flat Top Island, off Mackay. The likeness borne by the shells of these oysters, as illustrated in Chromo plate XIV., to the habitations of the Trap-door Spider, that may be dug out of the soil of the adjacent mainland, is so highly suggestive, that the popular title of "Trap-door Oysters" might be appropriately conferred upon them.

A small species of oyster, tolerably abundant in various parts of Moreton Bay and further north, which has in some instances encroached upon, and taken possession of, banks formerly occupied by the ordinary commercial species, is the *Ostrea crenulifera* of Sowerby. This variety is usually less than one-half the size of the commercial oyster; and, while somewhat resembling that in general shape, it may be distinguished from it by the more numerous, acuminately pointed, denticulations of the peripheral border, which are continuous, as in *O. cristi-galli*, with raised edges of the external surface of the shell and radiate from the hinge or umbo to the periphery. Like *Ostrea mordax*, this species is usually attached by the left valve. The colours of the shells of this small species are very distinct, being of a uniform greyish-white externally and greenish within. While too small for commercial purposes, the increase of *Ostrea crenulifera* on the banks should, as far as practicable, be kept down, as, if left undisturbed, it will spread over the most favourable breeding and spatting grounds, and, in addition, appropriate food material that would otherwise contribute to the nourishment of the more valuable species.

Although an oyster identical with the so-called mud-oyster, *Ostrea edulis*, of the more southern colonies has not been obtained from Queensland waters, a species bearing some resemblance to it has been sparingly captured by the author, with the aid of the dredge, in Moreton Bay, and in considerable abundance from Cleveland Bay and other northern districts, where it is utilised as food. A highly characteristic feature of this species is the single large indentation of its free border, which gives to its otherwise sub-orbicular shells a saddle-shaped contour. It has also a peculiarly thickened margin, the outer edge of which, when fresh from the sea, is coloured a delicate rose-pink. A figure, representing a profile view of the conjoined shells of this oyster, showing their characteristic curvature, is given in Chromo plate XIV., Fig. 6. It not having been found possible to identify this mollusc with any of the species hitherto included in the Australian list, it is here proposed to provisionally associate with it the title of the Saddle Oyster—*Ostrea sellaformis.* The largest specimens so far observed, measured as much as four or five inches in diameter, a size calculated to yield a substantial amount of "meat."

A species of bivalve classed among oysters in popular terminology, but which belongs to the genus Spondylus, demands brief attention, with reference to the fact that it is very unwholesome eating, if not absolutely poisonous. While occurring as far south as Moreton Bay, it is most abundant among the coral-reefs of the tropical coast-line. It may be easily recognised by the symmetrical ovate shape and convexity of its component shells (the lower or attached valve being particularly deep and cup-like), and also by the peculiar formation of the hinge-joint. The shelly teeth of this structure so interlock with one another that, while the valves open and close with the greatest readiness, they cannot be separated from one another without force, even after the death of the animal and the disintegration of their connecting ligament. The "flesh" of this false oyster when opened is of a pale pinkish hue. If partaken of in any quantity, in mistake for some ordinary edible variety, severe purging and nausea usually ensue.

THE ORDINARY COMMERCIAL OYSTER, *OSTREA GLOMERATA*—ITS INDIVIDUAL MODIFICATIONS.

The ordinary commercial oyster of Queensland, with which the appellation of the "Rock Oyster" is most popularly associated, is best known, scientifically, as the *Ostrea glomerata* of Gould. This bivalve, however, is subject to such an infinity of individual variations, dependent upon its special conditions of growth and environment, that some conchologists have been led to confer a separate specific name upon each most prominent variety. Since, however, there abound intermediate modifications which unite these, at first sight divergent, types into one harmonious series, the latest scientific opinion is in favour of including the whole within the single specific title above cited.

The diagnostic characters of this typical rock oyster, *Ostrea glomerata*, as embodied in Reeves's original description, are as follows:—"Shell thick, irregular, sharp-ribbed, with the margin dentated or lobed, very inequivalve; upper valve opercular, compressed, wrinkled, with thick concentric laminæ; lower valve cucullated, purple externally, white within, edged with purple or black; lateral margins denticulated; hinge generally attenuated, produced, pointed."

That modification of the species which is popularly known as the Dredge or Drift Oyster, in reference to the circumstance that it inhabits deeper water, from which it is collected with the dredge, has had conferred upon it by Sowerly the technical title of *Ostrea subtrigona.* Its distinctive features, as compared with those of *O. glomerata*, are thus enumerated by the authority quoted:—

"Shell sub-trigonal, oblong, or sub-quadrate, ponderous, rather narrowed toward the umbones, broad at the ventral margin, quadrate; margin strongly plicated, lower valve deep, greenish white, edged slightly with purple; without, radiately plicated, concentrically banded with fawn and purple; hinge acuminated, sides crenulated near the hinge. The sculpture of the shell is bold and large, and the square character of the ventral margin is striking."

Oyster-shells, possessing the characteristic features incorporated in the two foregoing diagnoses, may be found growing side by side in the same cluster, if collected from a bank exposed at ordinary low tide or dredged from a depth of three or four fathoms. A tendency nevertheless prevails, with the shallow water, tide-exposed, racial stock, to develop the more luxuriantly frilled and convoluted marginal border and brighter colours associated with the typical *Ostrea glomerata*, as illustrated by Chromo plate XIV., Fig. 8; while with those growing in deeper water, a smoother, more ponderous form, with often an abnormally elongated contour, and a more or less complete absence of the conspicuous coloration characteristic of the shells exposed to light and air, is found to predominate.

In another form, very prevalent among the oysters taken from deep water, or dredge sections, the prolongation and smoothness of the component shells are more conspicuously pronounced than in the typical dredge or drift variety, associated in the foregoing diagnosis with the title of *Ostrea subtrigona*, many specimens collected by the author being no less than three or four times as long as broad. This abnormal elongation, it would seem reasonable to anticipate, demonstrates a disposition on the part of the mollusc to grow upwards towards the light, much after the manner of a light-starved plant. That this tendency to elongate may be manifested at an early period in the oyster's life, was well shown by brood-clusters only a few weeks old, attached vertically to the dead valves of the mollusc Parallelopipedum, which were dredged from a depth of four fathoms in Moreton Bay. The same dredge haul that yielded these specimens brought up, however, a much more considerable number of brood specimens, agreeing strictly in contour with the typical form

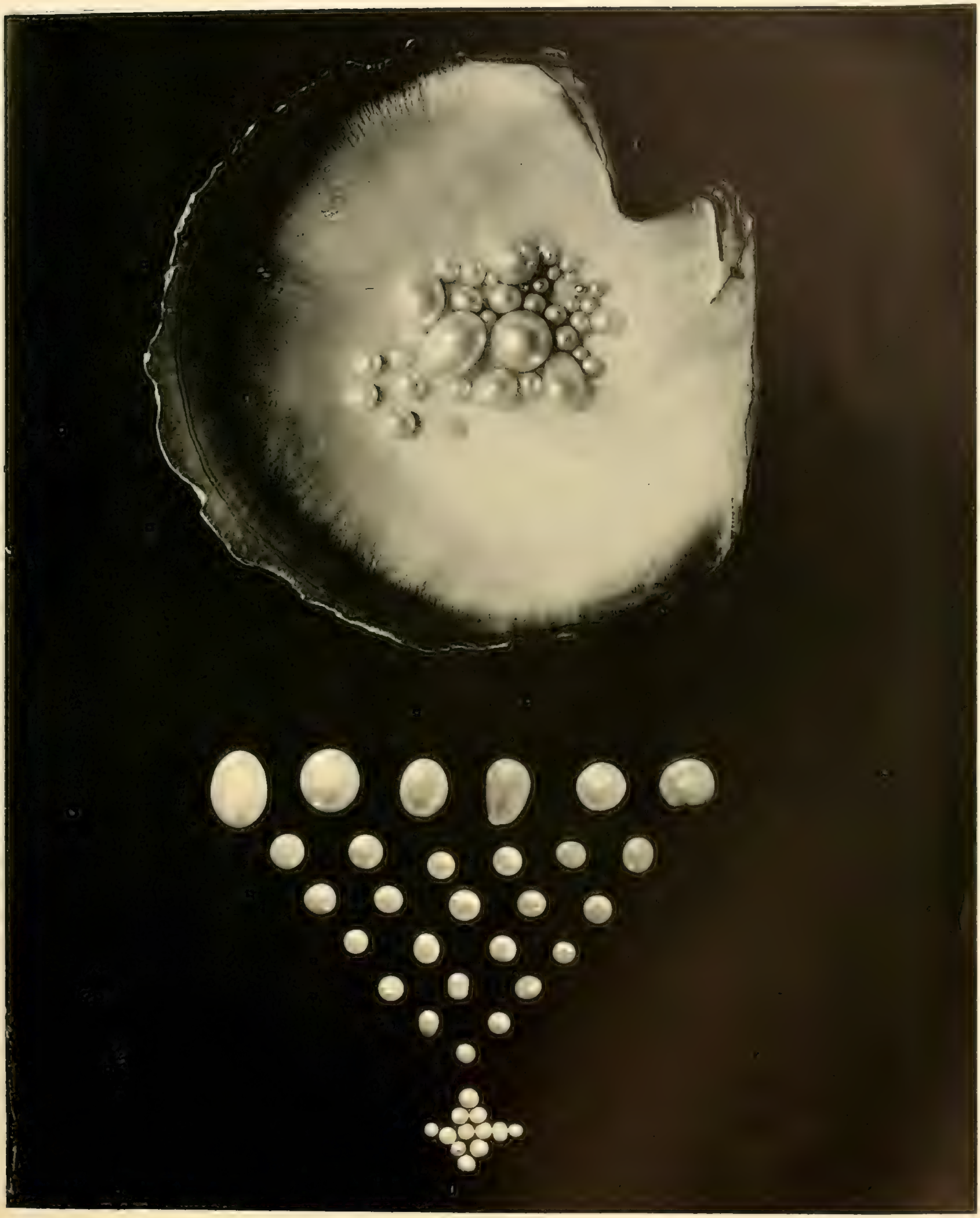
of *Ostrea glomerata.* Adult clusters obtained from a similar depth, moreover, contained both the normal and the elongated types in the same group.

A third notable variety of the ordinary rock oyster, *Ostrea glomerata,* is most typical of the northern area of its distribution. It is remarkable for its almost circular, or sub-orbicular, contour, with prominent radiating frillings and, most frequently, a deep cup-like excavation of the attached shell. This type of oyster is abundantly represented in the extensive banks and reefs in the neighbourhood of Keppel Bay, and is also dominant among those types growing on the mangroves in the Endeavour River, near Cooktown. It never attains to the large size of its southern congener, a shell having the capacity of a single fluid ounce being of abnormal dimensions. This modified form would appear to be identical with the type upon which, on insufficient evidence, the so-called *Ostrea mytiloides,* of Lamarck, has been established. That it is only a variety, however, of the common species, and not a distinct form, is abundantly shown by the fact that oysters approaching the normal triangular outline occur with it; while the orbicular variation, on the other hand, may not unfrequently be detected growing among the typical triangular southern race. Within the circle covered by the ordinary triangular, the orbicular, and the abnormally elongate modifications of *Ostrea glomerata* that have now been enumerated, the inclusion of any of the numerous intermediate local variations that occur will be an easy task.

One somewhat abnormal variety of *Ostrea glomerata* invites brief notice. This is the form represented by Fig. 10 of Chromo plate XIV., conspicuous for the slender spinous processes developed on the surface of its unattached valve, which communicate to it an aspect corresponding with that of certain of the Thorny Clams, genus Spondylus. There would appear to be little reason for doubting that this modified form is identical with the so-called *Ostrea spinosa* of Quoy; though its correct allocation to the position here allotted it is demonstrated by the circumstance that, where it occurs, every phase of variation between the spined and spineless shells is to be found. It is, moreover, only a young condition, the spines, as the shells grow older, becoming gradually obliterated. In this respect it recalls the earlier growth-phase of the mother-of-pearl shell *Meleagrina margaritifera,* delineated and described in association with the phototype plate No. XXXVIII., wherein projecting lappet-like laminæ are profusely developed over the surface of the shell. This spinous variety of the young of *Ostrea glomerata* has been observed by the author most abundantly among colony-growths attached to the aërial roots of the orange mangrove, *Rhizophora mucronata,* in the neighbourhood of Cairns, and also on rocks at the north end of Wide Bay, and in Keppel Bay.

OSTREA GLOMERATA.—COLLECTIVE CONDITIONS OF GROWTH.

Among the several natural growth-conditions under which the commercial oysters of Queensland occur in marketable quantity and dimensions, the "Bank" variety, in which the bivalve spreads itself over extensive level banks that are more or less uncovered at low-water, represents



R. Saville Kent, Photo. Waterlow & Sons Limited.

QUEENSLAND PEARLS. NAT. SIZE.

the most important. These "bank oysters" may be attached to stones, or dead oyster-shells known as cultch, or, as still more frequently happens, to the living shells of a peculiar species of whelk, *Potamides ebeninus*, Brug., whose name, with the aborigines of Moreton Bay, is that of "Toondah." This whelk, which grows to a length of three or four inches, is essentially herbivorous, feeding on the Confervæ, lower algæ, and other vegetable organisms that abound on the mud-flats so favourable to the growth of the oyster. The free-swimming oyster embryos or "spat" become attached in large numbers to the exposed dorsal surfaces of the whelk's-shell, and are carried about with it among the most luxuriant pasture grounds. Within a few months' time the oysters have increased to such a size and weight that the whelk is no longer able to travel with its burden; and where the ground is soft it sinks into the mud and perishes, leaving the living crown of oysters by way of a monument, to mark the position of its interment. Of the number of oysters originally adhering to the whelk, some four or five, representing the surviving "fittest," usually grow to maturity and marketable size. Examination of some very fine examples of whelk-oyster-growth obtained from Deceptive Bay, proved that the load of oysters carried by the living whelk frequently weighed as much or more than half a pound, while the whelk itself barely weighed an ounce. A characteristic illustration of a whelk oyster bank from the Moreton Bay district, is afforded by the photographic view reproduced on Plate XLI.A; while a whelk, Potamides, with an attached crop of young oysters is delineated in Fig. 9 of Chromo plate No. XIV.

An illustration of another oyster-bank, representing one of the rich oyster-grounds of the Bribie Passage, Moreton Bay, is given at Plate V., Fig. 1. It is noteworthy that the banks in this district are formed more exclusively of oysters attached to ironstone pebbles, lying upon a substratum of gravel and tenacious mud. They enjoy a high reputation for their shape, size, and flavour. Oyster-banks of a similar character exist in the most luxuriant natural conditions throughout Moreton and Wide Bays, the northernmost point of their occurrence being Rodd Harbour and "Seven-Mile Creek," a little south of Gladstone and Port Curtis. The oysters on these northern beds grow under conditions—on whelks or on separate shell or stone bases—precisely parallel with those of their southern congeners, but they do not, in that higher latitude, attain to so large a size. The experiment of transporting these smaller northern oysters to southern banks is now under trial, with every promise of a successful issue; though the considerable interval of, approximately, twelve months has apparently to elapse before the new growth commences which is necessary to bring them up to marketable dimensions.

Concerning bank oysters generally, it may be mentioned that this form of growth represents the most important one, from a commercial standpoint. Not only are the largest numbers of oysters sent to market taken from the banks, but bank culture furnishes employment and a livelihood to a very extensive section of the community. In this connection, it may be affirmed that probably in no other country in the world is so healthy, congenial, and non-laborious a means

of earning a substantial competency open to, and turned to practical account by, all classes, as that of bank-oyster culture in the Queensland oyster-producing districts of Moreton or Wide Bays. With a nominal rental, payable for ground cultivated and occupied for a homestead, with a climate that permits of dispensing with all but the most necessary form of raiment, and with fish procurable in such abundance as to substantially minimise the butcher's bill, no more perfect terrestrial elysium is probably at the disposal of small capitalists, having a sufficient means of maintenance for the first year or two that must elapse, before their oyster crops have increased to a remunerative extent.

That mode of oyster-growth which ranks next in importance to the bank series constitutes what is known as oyster-reef. This, in its most typical form, consists of a solid mass of oysters that may be several feet in thickness, raised to a higher level than the bank—the top being exposed at about one-quarter ebb. As a rule, the upper crust, representing some five or six to twelve inches in thickness, alone, of these reefs, consists of living oysters, the substratum being composed of the dead shells of their ancestors. These reefs, in their most characteristic state, rest simply on a clay or gravel basis, but are not unfrequently associated with a rocky outcrop as their starting-point. Oyster-reefs, while formerly abounding in Moreton and Wide Bays, are now represented in these localities in greatly diminished numbers. Their constituent oysters, in consequence of their crowded growth, are of small dimensions; but, on being broken apart and distributed on the banks, they soon increase to a marketable size. Such reefs have, consequently, formed one of the main sources for the collection of stock for cultivation on the banks, and this to such an extent that few, if any, reefs are to be found in their pristine massive condition throughout the oyster grounds of the southern district.

A highly characteristic view of a typical virgin oyster-reef, selected from those which occur in the neighbourhood of "The Narrows," between Port Curtis and Keppel Bay, is given on Plate XL. The oysters in this reef are accumulated in a solid mass four or five feet thick, their density being well shown by the portion which has been undermined by the current and has broken away from the parent heap. The originally horizontal superficial area thereby exposed, serves also to illustrate the rounded, or sub-orbicular, shape, previously alluded to, that usually characterises the growth of oysters where massed together in this more northern district. The basis of this luxuriant oyster-reef, and of others in the same locality, consists chiefly of gravel and coarse sand, overlying a tenacious clay, larger pebbles or small drift boulders, transported through the agency of flood currents, being here and there interspersed among the general mass.

Typical rock oysters (the bivalve occurring in masses attached to rocks) are well represented in the rocky outcrop with attached oysters at Burleigh Head, near the mouth of Tullebuggera Creek, a little to the south of Southport. The oysters growing under these conditions, though smaller in size than the "bankers," are often deep, cup-like, and excellent in

quality. Like those growing on the reefs, they are well adapted for separation and cultivation on the banks, though the tenacity with which they adhere to their rocky basis involves considerably more care and labour in their detachment.

What are known as "Mangrove" oysters, represent an important item in the Queensland growth-conditions of *Ostrea glomerata*. These are the oysters with which there originated the supposed travellers' tales, of earlier days, concerning oysters growing upon trees. The most typical and commercially important phase of mangrove oyster-growth, is represented by those instances in which the oysters affix themselves to the exposed roots and respiratory shoots, or so-called "cobblers'-pegs," of the white mangrove, *Avicennia officinalis*. By the process of accumulation they may increase, under these conditions, to such an extent as to constitute, where most favourably circumstanced, massive banks, scarcely less prolific than the typical reefs previously described. Such a mangrove oyster-bank in its most perfected luxuriance is illustrated by Plate XXXIX., representing a view taken in Keppel Bay. When growing in the prolific manner here represented, these banks constitute, as in the case of the typical reefs previously described, valuable material for segregation and artificial cultivation on the spot.

A second, and somewhat less prolific, variety of mangrove oyster-growth, is that in which the species is found attached to the luxuriantly ramifying aërial roots of the red or orange mangrove, *Rhizophora mucronata*, as illustrated in Plate XXXIX. Oysters on this description of mangrove more commonly occur in the northern area of distribution of the species; and in such localities as the mouth of the Endeavour River, near Cooktown, and at Bowen, Port Denison, constitute the almost exclusive representatives of the genus. This mangrove oyster occurs also in some abundance in certain parts of Wide Bay, such as the vicinity of the South Head. In consequence of its adaptation of contour to its supporting fulcra, this oyster is apt to develop a very irregular form of growth; if, however, it be moved at an early stage of its existence, and spread out under favourable conditions for culture on the banks, it has been found by systematic oyster-growers to well repay attention. This being the experience gained on the Wide Bay oyster-grounds, it may be anticipated that successful results would also accompany a like treatment of the variety, in its natural habitat, farther north. This anticipation is supported by the circumstances that oysters of larger, edible, dimensions and quality are to be gathered among the fallen *débris* lying around the mangrove trees, where, living more or less remote from one another, they have room for their shells to expand. Giving due weight to this fact, the author is of the opinion that remunerative banks, productive of oysters in at least sufficient quantities for local consumption, might be initiated, with stock derived from the mangroves, in these more northern districts. In the establishment of such experimental banks, attention should be given to imitating as nearly as possible Nature's own pattern, the banks being formed, not on open sun-exposed flats, but within that umbrageous shelter of the mangrove trees where the species attains to its finest development in these higher latitudes. The conditions above indicated obtain,

on a sufficiently extensive scale for the practical application of the above suggestions, in the estuary of the Endeavour River, in the neighbourhood of Cairns, and at the mouths of the several creeks debouching into Port Denison, in the neighbourhood of Bowen. It may be here mentioned that the foregoing variety of mangrove-oyster grows so luxuriantly in favourable localities in the neighbourhood of Rodd Harbour, that as many as twenty or thirty two-bushel bags, suitable for cultivation on the banks, have been gathered from a single tree.

The collective growth forms of *Ostrea glomerata*, known as dredge and drift oysters, remain to be noticed. The first-named title is applied generally to all oysters growing below the level of usual ebb-tide, that of drift oysters being more exclusively associated with those lying loose and separately at the bottom of the water, and which are supposed to have been washed from the banks or beds, and to have drifted here and there at the mercy of prevailing currents. The tendency of the dredge, or deep-water, oyster to develop a more elongate shape with a much smoother and less crenulated marginal border has been referred to on a previous page. With the typical "drift" variety the tendency to develop an abnormally massive shell, through continued erosion, is especially noteworthy, instances occasionally occurring in which the lower, or right, valve weighs as much as half a pound avoirdupois. The concavity of such a shell is rarely of sufficient size to contain more than a single fluid ounce, while the corresponding shell of a fine, cultivated "bank" oyster, having an internal capacity of two fluid ounces, yields an average weight of scarcely three ounces. Dredge and drift, as compared with bank, oysters contribute to a less extent to the oyster trade of Queensland, the relative proportion, so far as it can be ascertained, while formerly considerably larger, being now about 20 per cent. In this respect, the Queensland oyster fisheries present a marked contrast to those of the neighbouring colony of New South Wales, in which the dredge and drift varieties have, until within recent times, represented the most important commercial factor. Among the arguments that have been advanced in favour of the specific distinctness of the deep-water oyster, or *Ostrea subtrigona*, as it is designated by those who advocate its distinction, is the one that this deep-water form will not live if transported to the tidally-exposed banks, any more than will the bank variety if consigned to deep water. If the transition is made unseasonably, unfavourable results are likely to ensue. Where the change is judiciously effected, no difficulty is experienced in cultivating dredge or drift oysters on the ordinary banks, or *vice versâ*. In various localities in Moreton Bay, and notably at the Breakwater in Nerang Creek, oysters grow in a continuous sloping series, from a depth in which they are covered by a fathom or more of water to the tops of rocks that are dry with every ebb. Oysters taken from these exposed rocks are, moreover, systematically and successfully laid down as "cultivation" on a neighbouring dredge section, where they are covered by at least two fathoms of water. No more practical evidence, probably, could be adduced, in demonstration of the specific identity of the deep-water and tidally-exposed series. Parallel examples of a species of oyster adapting itself to the varied conditions of either total or partial submersion, are afforded by the typical European oyster, *Ostrea edulis*, or

its Australian variety, *O. Angasi*, as it occurs in the more southern colonies. In the former instance it may be dredged in the open sea at a depth of as much as twenty fathoms, being then represented by the large rough form commercially known as Channel oysters, or it may be gathered, somewhat rarely in England, but more abundantly in the warmer waters of the Channel Islands or on the neighbouring coast of France, adhering to the rocks, after the manner of *Ostrea glomerata*. It is this same species, moreover, in its coarser, natural, form, ordinarily taken with the dredge, that is cultivated on so extensive a scale on the tidally-exposed foreshores of France, and that is transformed, through a long and tedious course of manipulation, into the costly world-renowned Colchester or Whitstable "Native." The fact that the drift or deep-water form of *Ostrea glomerata*, as it occurs in Australian waters, is most commonly found separated by a considerable interval of space from its congener of the rocks or banks, is probably explained by the circumstance that the strong current or scour which is essential for its healthy existence is wanting in the intermediate barren areas. A deep well-scoured central channel, in which the mollusc flourishes, is commonly separated from the equally clean, tidally-exposed, and current-swept, littoral margin, by an intervening area of stiller water, within which mud and sedimentary matters accumulate to an extent rendering it unsuited for oyster growth.

In connection with the subject of "dredge" oysters, it is worthy of mention that the theory has been advanced that profitable beds of the ordinary commercial variety, *Ostrea glomerata*, probably exist in deep water on the open coast-line of Queensland and New South Wales. The evidence in support of this theory is founded on the circumstance that oysters have been recently dredged under such conditions, off the Victorian coast-line, in connection with the prospecting cruise of the steamer, *Lady Loch*. The successful results there obtained were the outcome of a report to the Victorian Government made by the author on the Victorian oyster fisheries, in which, in consequence of the traces of the existence of oysters observed by him along the Ninety-mile Beach and other portions of the coast, he foretold their probable presence in extensive beds, and recommended to the Government that experimental dredging operations should be undertaken with the view to their discovery. The species of oyster in this instance, however, was the so-called mud oyster, *Ostrea edulis*, var. *Angasi*, of which the largest natural beds are found in the open sea. The Queensland and New South Wales commercial form, *Ostrea glomerata*, is an essentially estuarine or brackish water type; and, so far as the author's investigations and enquiries have extended, it is never met with in water that is permanently salt. There is consequently little or no chance of success attending any attempt that might be instituted to dredge for this oyster on the open seaboard. With relation to the salinity of the water most favourable for the growth of the Queensland commercial oyster, the author has demonstrated, as the outcome of a prolonged series of investigations, that a mixture of one portion of fresh water to four of standard salt water, is the most favourable mixture under which it will flourish. It frequently happens that the oysters in many localities are, during times of drought,

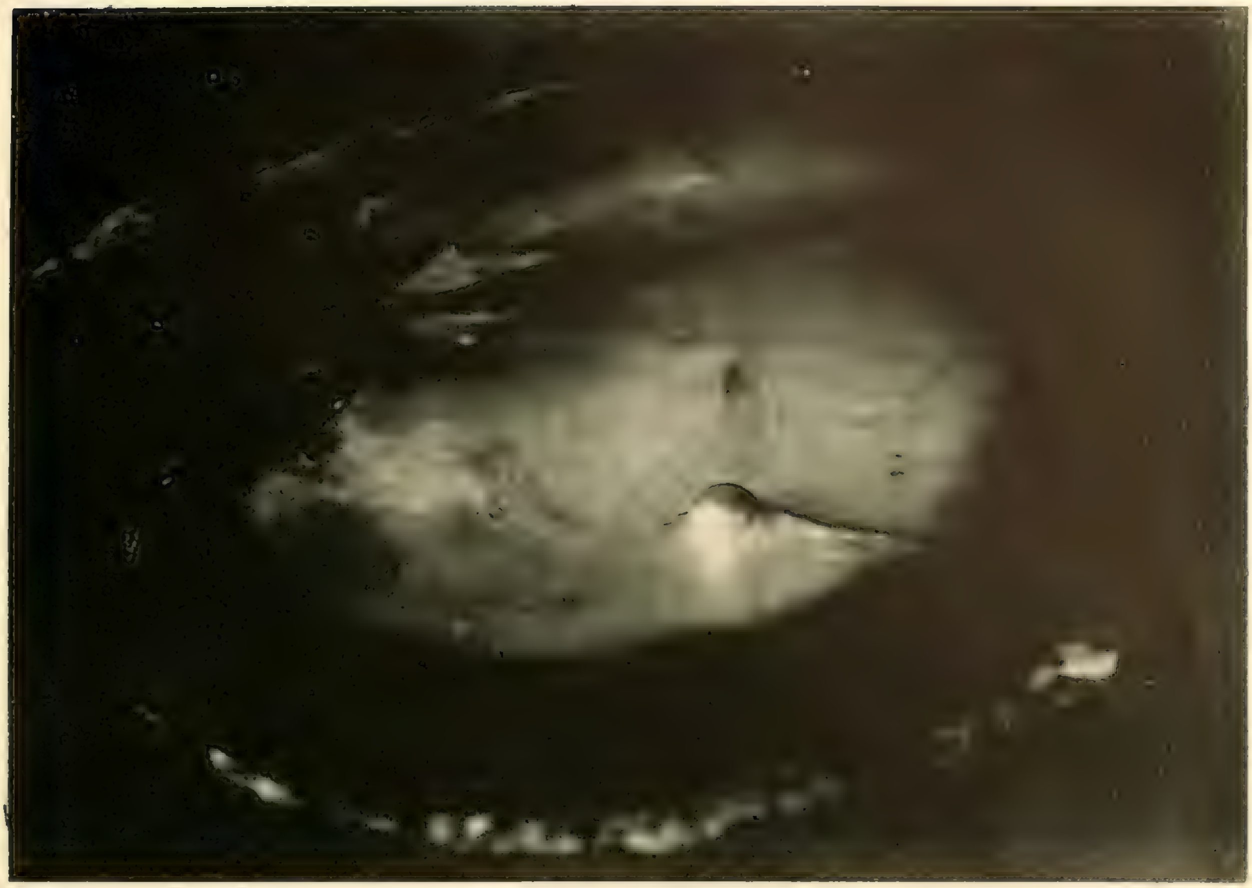
immersed, for considerable periods, in water that is entirely salt, and, conversely, during floods, in purely fresh water. Should the latter condition, however, obtain for over a week, disastrous results usually ensue, more especially with relation to the immature stock.

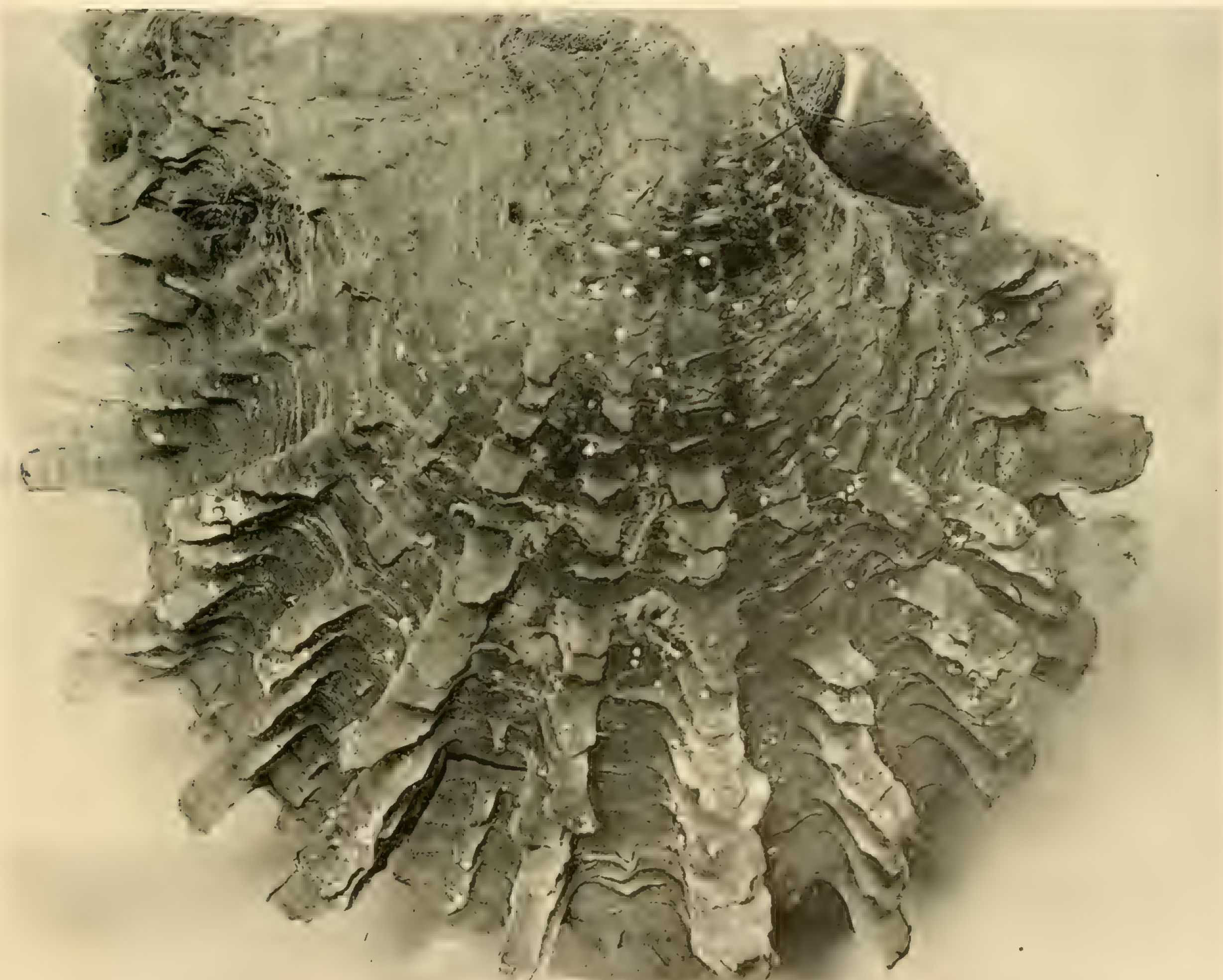
Experiments were also undertaken by the author with the view of ascertaining the action of water of varying density upon the newly-born oyster embryos, or spat. When ova and milt were commingled in purely salt water it was found that but a very small portion of the ova were fructified, and that the subsequent development of these few proceeded very slowly. Another series placed in water consisting of equal proportions of salt and fresh, exhibited the most active vitality, all the ova being fertilised and speeding quickly on their developmental career. In a third series experimented with, the proportions of water used were one part of salt water to three of fresh. In this instance, the ova were entirely deprived of life, and soon commenced to disintegrate. This last experiment assists much towards demonstrating the deleterious action exerted by floods on the embryonic brood, when the proportion of fresh water, as in an example tested, is greatly in excess of the salt. It is at the same time worthy of remark that the access of flood water appears to give a pronounced stimulus to the oyster's reproductive faculties; an abundant fall of spat commonly follows after the advent of a flood, and this thus compensates to a considerable extent for its ill-effects upon the previously developed brood.

ARTIFICIAL CULTIVATION.

The artificial culture ot oysters, as understood and practised in connection with the Queensland oyster fisheries, and as applied to the single species, *Ostrea glomerata*, has consisted essentially, hitherto, in collecting the immature brood (locally known as "cultivation"), and separating and spreading it out on banks and beds, where the conditions are more favourable for its development to marketable dimensions. One of the most important sources from which this ware, or "cultivation," is derived, is represented by the tidally-exposed reefs described on a preceding page, whence, with the least expenditure of labour, vast quantities can be speedily collected. Not only have the oyster-reefs and banks throughout Moreton and Wide Bays been laid heavily under contribution for the supply of this "cultivation," but large brood consignments for the same purpose are now being imported from as far north as Rodd Harbour and Keppel Bay.

Such is the enormous fecundity of the Queensland commercial oyster, and the extent of the areas available for the fixation and development of the spat, that little or no occasion has hitherto arisen for resort to the more elaborate methods of oyster cultivation practised in European waters, and which comprise, as a most fundamental principle, the provision of special apparatus for the capture of the embryo brood. Sufficient, however, though the supply may be to meet the existing demand, it may be predicted that, with increased home consumption, and a greatly extended export trade, such as may be reasonably anticipated in the no very distant future,





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MOTHER-OF-PEARL SHELLS,
AND ARTIFICIALLY PRODUCED PEARL. NAT. SIZE.

some more scientific method than that hitherto in force will be in request, for saving some portion of the vast amount of oyster spat annually produced, which, under present conditions, is literally lost at sea. By the lowest estimate arrived at by trustworthy investigators, it would appear that each mature female oyster produces at least from 2,000,000 to 3,000,000 embryos at the annual breeding season. It has been further estimated by Möbius, concerning the European species, *Ostrea edulis*, that of the vast number thus produced less than one individual in each of these million embryos runs the gauntlet of the innumerable perils that beset its career, and arrives at maturity. The greatest amount of mortality that decimates this embryo host is undoubtedly associated with their failure, after the maturation of their shells, to fall upon ground or materials upon which they are able to effect an anchorage. Unless the surface on which they fall is clean, and entirely free from slime or sediment, adhesion is not accomplished, and the embryo either drifts away or sinks into the mud, or sand, to perish. The aim of the systematic methods of oyster culture in operation in European, and most notably in French, waters, is to encompass the salvage of the vast shoals of embryonic waifs that would naturally run to waste. The accomplishment of this highly desirable object is effected mainly through the provision of apparatus styled "collectors," that form attractive media for the adhesion of the spat. These collectors are constructed of varying form and material. From the earliest days of oyster culture, the old shells, or "cultch," of the oysters originally raised for the market, have been systematically saved and placed upon the beds with gratifying results; such materials constitute, in fact, one of the most natural media for the attachment of the embryo brood. Faggots of wood, best known by their French title of "fascines," have been, and are still, extensively used in French waters and at the ancient oyster-breeding establishment of Lake Fusaro in Italy, for a similar purpose. The most efficient description of artificial spat collectors that have been invented are, however, probably those first introduced into the French oyster-grounds by M. Coste, which consist of a cheap form of earthen tile, the under surfaces of which are coated with Portland cement. The calcareous constituents of the cement, when set and seasoned, are so analogous to those of the parent oyster shells that the embryo brood adheres to it with equal readiness. A second form of collector, successfully employed in France, consists of cemented boards, united by their long edges in ridge-tile fashion, and strung one above another in sets; when anchored by a stone, they are allowed to float freely in the current. This "ridge-tile" form of collector was employed by the author with fair results, in connection with the Government Oyster Reserves of Tasmania, established under his supervision in the year 1885, with the object of resuscitating the (at the time) exhausted oyster fisheries of that colony. Figures, with a description of this form of collector, were published in the author's report to the Tasmanian Government for that year; and, acting on the information therein contained, similar collectors were experimentally placed on one of the cultivated banks in Moreton Bay. These collectors were soon covered with spat; but, being set in

shallow water, they fell to the ground as each tide receded, and the young oysters became a ready prey to crabs and whelks. This type of collector has also the drawback of getting water-logged, and sinking to the bottom by its own weight, after prolonged immersion, when the attached brood runs the same risk of premature destruction by its natural enemies or by the accumulation of sand or mud.

As an improvement upon, and simplification of, this ridge-tile collector, the author subsequently made use of the rough form of board known throughout the Australian colonies as "split paling." Such palings—four feet long, eight inches wide, and one inch thick—were readily procurable at the low price of from eight to ten shillings per thousand. With a brick or stone attached by wire to each end, on the under side, the surface between the two bricks coated with cement, and a loop of wire fixed to the upper surface to serve as a handle, whereby they could be either easily carried, lifted from, or lowered to, the bottom of the water with the aid of a boat-hook, they were found to constitute the most convenient and economic form of collector that could be desired. The bricks or stones on the under surface served the double purpose of anchoring the collectors securely to the bottom of the water, and they at the same time raised the cemented surface above the reach of predatory crabs and whelks. In practical application, these paling collectors were found to possess all the efficiency of the French tiles, with the advantage of a far greater economy in cost. The tiles, with individually smaller superficial areas for the attachment of the spat, cost in France about £2 per thousand, and could scarcely be produced in Australia for double that price. In order to test the efficiency of the "split paling" collector in connection with the Queensland oyster, *Ostrea glomerata*, a few samples were constructed and experimentally placed on ground, at a spot where a few mangrove oysters already existed, near the mouth of Nerang Creek at the southern end of Moreton Bay. These collectors were deposited in the month of July, 1890, and within three to four months from that date they were literally encrusted with oyster brood, having shells, which averaged one inch in diameter. Two months later, a large portion of these oysters measured individually as much as two inches in their longest diameter; and, being loosely attached by the butt-end, they were ripe for detachment and distribution on the ordinary cultivation banks. As many as 2,000 young oysters were thus found attached to a single collector, being the equivalent of what, in the ordinary course of development, would, by the end of another eighteen months, represent a standard two bushel-bag of marketable oysters.

Although the general employment of artificially prepared spat collectors upon the Queensland oyster banks, as here described, is not recommended, and would scarcely be profitable under the existing abundant supplies, and the extensive natural spawning grounds, at the disposal of the leading lessees of the oyster fisheries, there are undoubtedly circumstances, and conditions, under which their introduction would prove of value. With the aid of these and kindred collectors,

however, miles of now barren, unremunerative, mud-flats, in both the Moreton and Wide Bay districts, might be made to produce an abundant harvest; while, small selectors having foreshore allotments, at present yielding them no return below high water-mark, would have at hand the ready means of substantially augmenting their incomes. That in the no very distant future the employment of artificial spat collectors will be desirable, if not obligatory, as a means of supplementing the natural supplies, and meeting the increased demand for both home consumption and export that is likely to arise, is a conclusion, indeed, that can scarcely be avoided. The more immediate necessity of resorting to artificial methods for collecting oyster spat, it may be observed, has been strongly advocated by the Moreton Bay Oyster Fisheries Inspector, Mr. C. S. Fison. On page 4 of his report for the year 1886, among a list of amendments recommended for the better regulation of the oyster fisheries, a prominent position is allotted to the compulsory employment, by oyster-bank lessees, of artificial methods of spat catchment.

It would appear desirable, at this juncture, to make a brief allusion to the section on oyster cultivation included in the same District Inspector's Report for the year 1890. On pages 3 to 5 of the report referred to, extensive quotations are made from letters treating on the subject, contributed by a Sydney oyster merchant to the Sydney Press. The general tenor of these letters is to depreciate the results that have been accomplished by methods of artificial cultivation in France. These results are, in point of fact, so grossly misrepresented as to make it appear that the system is itself a failure, and that no success could attend its introduction into Australian waters. The acceptance and republication of these letters, in all good faith, in an official report, as embodying the latest and most accurate information on the subject of oyster culture, is necessarily calculated to mislead the public, and to discourage any efforts which might be made to profit by the highly successful results actually accomplished on the French sea-board. It is with the object only of counteracting so undesirable an influence, that a brief statement of the actual facts, with accompanying statistical figures, is herewith submitted. In the first place, it would appear that the data upon which the letters above referred to are based, were derived from the Government report on the oyster fisheries of Ireland, dating so far back as the year 1870; at about which time, as testified to by witnesses engaged to collect evidence, the French oyster fisheries were undoubtedly in a very declining state. The cause of that decadence, which is fully explained in the report, was the avariciousness of the oyster-growers, who stripped their beds to such an extent, to supply the markets, as to leave an insufficient quantity for the purposes of propagation. This error, however, was corrected as soon as recognised, with the result that within a very few years the French oyster fisheries had not only regained their former position, but had eclipsed previous years in productiveness. The accompanying figures, derived from the French statistical returns, sufficiently substantiate this statement. In the year 1873 the official value of the oyster produce of France was estimated at 2,447,565 francs, or roughly £99,000.

For the three succeeding years the produce and value of the same fisheries are given as follows:—

	Oysters taken off beds.	Value in francs.	English equivalent.
1874	104,731,350	7,727,000	£309,080
1875	227,640,212	11,247,416	£449,896
1876	335,774,070	13,226,296	£529,051

In the year 1887 (cited as furnishing the latest statistics immediately available), the total number of oysters taken from the French fisheries is quoted at 375,000,000, showing that the magnificent record of the year 1876 has been beaten.

Among the evidence brought forward in the Sydney letters, with the view of depreciating the efficacy of the French system, much stress is laid upon the circumstance that, some twenty years ago, the Hon. Thomas Holt, recognising the value and capabilities of that system, undertook, at an expense of some £10,000 though unfortunately without success, the construction of extensive culture ponds, or "claires," at George's River, New South Wales, for the cultivation of oysters on the same principle. The causes that led to the failure reported, however, were not attributable to the system, but to the fact that a species of oyster differing essentially in form, habits, and methods of propagation, from the European type, was experimented with. Having recently availed himself of the opportunity of inspecting the extensive "claires" constructed by Mr. Holt, the author is of the opinion that they are altogether unsuited for the culture of the Queensland and New South Wales commercial oyster, *Ostrea glomerata*, which was the subject of experiment. On the other hand, they would in all probability prove highly suitable for that special fattening process of *Ostrea edulis*, for which alone these claires are utilised in France. These structures, in France, take the form of shallow ponds of from twelve to eighteen inches in depth, and are so connected by means of sluices with the sea, that fresh streams of salt water obtain access to them only at spring-tides; the water throughout the intervening periods remaining completely stagnant. It is through the culture of the French oyster under these special conditions that that green coloration of the oyster's tissues is acquired which commands for it so high a price in the Paris market, the colour being due to the character of its food, which consists almost exclusively of microscopic plants known as diatoms, and the spores of confervoid algæ. This special claire system of oyster culture is in no way suited to the Queensland bivalve.

Oyster culture on the French system, on the other hand, in so far as it consists of providing supplementary material, or apparatus, for the catchment of the redundant supplies of spat, is undoubtedly worthy the attention of all oyster-growers. Whether this material takes the simplest form of the returned parent shells or cultch, or of tree-branches or fascines, or of cemented tiles or boards, but one result has to be accomplished; and it resolves itself to a question, simply, as to which of these can be most economically or profitably employed on the areas under cultivation. In this direction, it will be found that different descriptions of oyster-ground yield the best results in association with diverse descriptions of collectors. On those beds and banks which are more

or less completely submerged, and over which there is a sufficient scour to prevent the accumulation of sediment, old oyster shells or cultch constitute the most convenient and efficient form of spat collector available. This material, however, if laid on muddy banks or where there is an insufficient circulating stream, becomes speedily covered with slime and sediment, and is, in such a condition, useless as a spat-trap. The *sine quâ non* of successful oyster spat deposit, is the existence of a perfectly clean surface for the embyro oysters to adhere to. On the oyster-grounds in English waters, such as Whitstable and Herne Bay, where the natural beds consist mainly of the old shells or cultch, the surface is continually worked over with the dredge, with the express object of laying bare new and clean shell surfaces, for the attachment of the embryo brood.

The form of collector next demanding attention is that of fascines or faggots, composed of boughs and branches of various sorts of timber trees. Collectors of this description are essentially fitted for employment on oyster-grounds where they can be kept continually floating or submerged below the surface of the water. The drawback to the use of fascines, or of tree branches in any form, is their liability, on exposure to light, to become speedily coated with slimy vegetable growths that leave no foothold for the young oysters. Considerable differences are, however, manifested by distinct kinds of trees, with reference to their attraction for oyster spat. The commoner Australian gums, Eucalypti, and wattles, Acacias, are apparently distasteful, on account of the pungency of the essential oils and essences they continue to exude, even after prolonged submersion; and they but rarely become encrusted with oyster brood. The Coniferæ, including the cedars and cypress-pines and also the She-Oaks, or Casuarinas, have, on the other hand, been found in practice to yield more favourable results than any other timber, and that more especially in experiments conducted by the author upon the artificial propagation of the Tasmanian oyster. The readiness with which the Queensland species naturally adheres to the large branching aërial roots of the orange mangrove, *Rhizophora mucronata*, would seem to indicate that this material would form an excellent one for the systematic construction of fascines.

To render fascines more efficacious as spat collectors, the boughs of which they are composed, as used in Europe, are not unfrequently washed over with cement. This modified form of fascine leads to those descriptions of collectors in which cemented surfaces are exclusively employed. The most prominent of these are the cemented tiles first employed by M. Coste, by the aid of which miles of barren mud flats on the coast of France have been converted into mines of wealth, giving employment to thousands of individuals. Such collectors are eminently adapted, and were originally constructed, for employment on banks or flats that are left uncovered at ebb-tide, and they are totally unsuited for manipulation beneath the water.

The peculiar advantage of cemented tiles, and of all forms of collectors constructed on the same principle, consists in the fact that as the relatively large cemented superficies lie on the under surface of the collector, the latter, when in position, remains almost permanently clean and ready

for the adhesion of the spat. Such collectors are consequently well adapted for employment on mud flats, where there is much sedimentary deposit, and under conditions in which other forms of collectors would be useless.

The "split-paling" collectors, first introduced by the author in the colony of Tasmania, as the nearest approximate substitute for tiles, have, as explained in a previous paragraph, proved in all ways equal to the latter as spat collectors; and in various other directions they possess distinct advantages. Their price of 10s. per 1,000 renders them cheaper for the purpose than any article previously employed. With attached wire handles, they are more convenient for handling on the exposed banks, and can, in addition, be easily deposited in or raised from water of a fathom's depth. Their individually larger superficial area entails a considerable saving of labour in their manipulation; while, as indicted on a preceding page, the circumstance of the cemented surface being raised by the attached bricks or stones some few inches off the ground, secures to the young oysters an immunity from the attacks of crabs, whelks, star-fishes, and other enemies, to which they are exposed when the cemented surface, as in the case of tiles, is in immediate contact with the sea bottom.

The "split-paling" type of spat collector has, in fact, after an experiencce of its successful application under a variety of conditions, proved to be the most convenient and economic form to employ in Australian waters, and it may be characterised as an essentially Australian implement. Sawn boards may, as a matter of course, be fashioned into collectors of identical form and efficiency, but at many times their cost—the relative price of the respective materials averaging 20 feet for 1d. for the split palings, and 1½d. per foot for the sawn wood. In practical use, the split palings are further found to possess an advantage over the sawn material, as the roughly parted natural grain of the wood furnishes a more favourable base for the attachment of the cement. When split to order, for this purpose, they should average at least an inch in thickness, and have as rough a surface as it is possible to obtain. Where split palings are not procurable, rough discarded rails or boarding of any description, such as are usually abundant around every settlement, may be pressed into service and be made to do good duty, before final condemnation as firewood. In the preparation of these collectors, the palings or boards should be soaked for a day or so in water, in order that the grain may swell to its full extent before the application of the cement. Should this precaution be neglected, the cement will not adhere to the wood. Salt water is as good as fresh for mixing the cement, and, as the process may be most conveniently performed at the water's edge, in the immediate neighbourhood of the beds under cultivation, this proves a distinct advantage. From experience gained by the use of these collectors in Queensland waters, it may be observed that about half-tide mark represents the zone within which the most abundant harvest of spat can be gathered, and this at all times of the year, though the months of February and August are more especially propitious for the purpose.

On their first attachment to the cemented collectors, it will be found that the young oysters

adhere to the cement by the entire surface of the attached shell. After attaining about one-half of an inch in diameter, the free edges of the shells commence to grow outwards; and this direction of their growth is continued until, at an age of about six months, they project an inch and a-half or two inches from the collector. At this stage, the young oysters may be easily detached with or without the cement, and be laid on the banks as ordinary "cultivation." The collectors may then be re-cemented and re-laid, for the catchment of a second crop. Cemented slates have also been found to prove very efficacious spat collectors, and they most nearly approach the French tiles. Slates, procured as an ordinary market article, are too expensive for general employment. It sometimes happens, however (as occurred with the supply experimented with), that condemned lots may be obtained at but a little over the cost of carriage, direct from the quarries. In utilising slates for this purpose, it has been found most convenient for manipulation to use them in combined series, wiring sets of half-a-dozen or so to each side of a ridge-shaped frame constructed of light saplings cut to four or five feet lengths.

Characteristic illustrations, from photographs, of the Australian "split-paling" oyster-spat collectors are introduced at page 278, as a tail-piece to the present chapter. One figure depicts the collector in its newly-constructed form, ready for introduction into the water, and the second one represents a collector, which, after remaining in the water for three months, is completely covered with oyster brood.

DESTRUCTIVE AGENCIES AND DISEASES.

Among the enemies from whose attacks the Queensland oyster-grower suffers serious loss of stock, the small boring whelk, *Urosalpinx paviæ* of Crosse, must be awarded a prominent position. The destructive influences exerted by this mollusc are parallel to those wrought by *Murex tarentinus* and *Nassa reticulata* on the European oyster-beds. The shell of the Queensland borer, while much like that of the last-named European species, is more slender, and has a distinct violet-coloured lining to the mouth aperture. The young oyster, from its earliest attached condition up to about one-half of its adult growth, is much subject to the ravages of this foe. Not unfrequently, it is so abundant and predaceous that almost the entire brood-stock on a bank, or from dredgings, investigated, was found to be destroyed by this borer. Mature oysters, even, are not exempt from the attacks of this enemy, one of the shells in the typical cluster illustrated by Chromo plate XIV., Fig. 8, exhibiting at "*A*" the symmetrically circular hole by which the Urosalpinx has gained access to its prey. The drilling operation is performed by these boring molluscs with the aid of a toothed ribbon, technically known as the "radula," which is enclosed within, but can be partly protruded from, the buccal cavity. It has been ascertained by direct experiment in connection with the European species, *Murex tarentinus*, that the mollusc takes about half an hour to pierce the shell of a young oyster one month old, and eight hours to perforate a matured one of three years' growth. The only practical remedy for the destruction of this pest, so far employed, is hand

picking; a tedious process, but it can be carried into practice with considerable success on the banks, especially with the aid of children, who soon become great adepts in detecting and collecting the unwelcome intruder. By such means, the borer has already been fairly exterminated in certain of the most carefully-cultivated banks. This species of boring whelk has been observed in abundance on the oyster-banks, as far north as Rodd Harbour and Seven-mile Creek, where it also levies a heavy toll on the growing brood. The interesting discovery was recently made and communicated to the author by Mr. E. Kelk, of Brisbane, that another gasteropodous mollusc, *Natica plumbea*, preys upon the Urosalpinx. This species is of larger size than the borer, with a smooth snail-like shell. In the living state, a large fleshy fold, technically termed the "mantle," is protruded from the shell, and forms a continuous border of about an inch in breadth around the creature as it crawls. With this mantle it was observed by Mr. Kelk to seize and envelope the living borer, and to retain it within its folds, until, by muscular force, it had dragged from its shell and devoured its victim's body. Should this recorded habit of *Natica plumbea* prove, on further investigation, to be its customary one, a valuable remedy for the ravages of the borer will have been discovered in the collection and placing on the beds of quantities of Naticæ to devour and keep them in check. Before the application of this specific, it will be desirable to ascertain whether, under certain conditions, such as the scarceness of Urosalpinx, the Naticæ may or may not develop a latent taste for young oysters. This precaution is the more necessary since, in various standard natural history works, small bivalve molluscs are enumerated as constituting the ordinary food of many species of the genus Natica.

Starfishes of all descriptions, but more especially the ordinary five-rayed varieties, Asteriadæ, are universally held up for condemnation, as representing the most insatiable foes of the oyster tribe. Whether this wholesale condemnation is a just one, there are some reasons for doubting. In many instances it has been observed that the starfishes were merely acting as scavengers, and preying on dead or dying bivalves. The direct experiment was carried out by the author, some years since, in one of the large English public aquaria, of keeping oysters and starfish, including the accredited most aggressive species, *Asterias* (*Uraster*) *rubens*, in the same tank. The pre-supposed aggressors and their helpless victims were thus maintained, side by side, in perfect health, for many months, without a single instance occurring of molestation of the oysters on the part of the starfish. The Echinoderms, however, demonstrated their possession of normal healthy appetites, by feeding freely on portions of cut-up fish occasionally placed in the tanks. How far this vindication of the starfish's character would hold good in association with the common shore species of South Queensland has yet to be demonstrated. In the interim it is desirable, in the interests of the oyster-grower, to recommend the clearance of this intruder as far as possible from off his beds or banks. In this connection, a suggestion concerning the destruction of starfish may prove acceptable. It is by no means an uncommon practice among oyster-cultivators, on bringing up starfish in the dredge, or finding them on the banks, to rip them in pieces and cast them aside, or

MANGROVE OYSTER BANK, KEPPEL BAY.

W. Saville-Kent, Photo.

Waterlow & Sons Limited.

MANGROVE OYSTERS, ENDEAVOUR ESTUARY.

into the water again, under the impression that their life is destroyed. As a matter of fact, each of the five finger-like processes separated from the starfish's body is capable of growing into a fresh starfish, so that by the process of dismemberment the further multiplication of the species is accomplished. If only the lambs' tails docked by the Australian pastoralist could be induced to re-grow the lamb, on the same happy principle, millionaire squatters would soon become a drug in the market. To encompass the certain destruction of the starfish, it is desirable that they should be carried to land and be deposited above the reach of the tide. They may also be killed immediately, by immersion in fresh water.

Certain species of sea-urchins, or sea-eggs, Echini, have been occasionally accredited with oyster-eating proclivities. Their habits, however, are essentially herbivorous, and the only injury they might possibly, but very improbably, do to oysters is that of piercing the very young and fragile shells, with their sharp spines, in passing over them.

Many varieties of Queensland fish prey more or less extensively, though not exclusively, on oysters. Among these may be mentioned the family of the toad-fishes, Tetradons, porcupine fish, Diodons, leather-jackets, Monacanthi, and the several varieties of breams, Pagridæ. The most destructive fishes on the oyster-banks are, however, undoubtedly the Sting-rays, or "Stingarees" as they are popularly denominated, belonging to the shark tribe and referable to the genus Trygon. The common dark brown species, *Trygon pastinaca*, is probably the greatest delinquent in this direction. It abounds on the low-lying banks throughout the oyster-growing districts, and commits serious havoc among the young stock, under the action of its pavement-like crushing teeth. A more typical oyster-eating member of the shark tribe, that abounds in the southern colonies and is occasionally taken in Moreton Bay, is the so-called Port Jackson shark, *Cestracion Philippi*. It is of a tawny-brown colour, with an abnormally large head and projecting brow-ridges, and has a strong sharp spine developed in front of each of the two dorsal fins. It rarely exceeds a length of five feet, but is provided with powerful crushing jaws of greater strength even than those of the Rays, with which it easily breaks up the largest oyster-shells. On certain of the Tasmanian Government oyster reserves, and private beds, it has wrought such havoc, that the oysters were only saved from entire destruction by fencing them round with wire netting. With reference to its oyster-eating proclivities, the species is known in Tasmanian waters by the name of the "oyster-crusher," while in some parts of Victoria it is called the "pig-fish." In testimony of the peculiar hardness of its palate, it may be mentioned that in the neighbourhood of Port Jackson, New South Wales, it feeds extensively on the spine-covered sea urchins, its teeth being frequently stained a bright violet hue through its predilection for this piquant diet.*

A species of boring sponge, allied to *Hymeniacidon celata*, has here, as in European waters, to be included among the enemies of the oyster. Its attacks are, however, confined almost exclusively

* In view of this, it is interesting to remark that Howes has recently drawn attention to the fact (*Trans. Liverpool Biol. Soc.*, Vol. VI., p. 124) that the interior of the mouth of this fish is beset by a series of uniformly diffused minute teeth.

to old shells in deep water, which it honeycombs in every direction. This parasite is soon got rid of, by the exposure of the affected oysters to light and sunshine on the banks.

Several species of birds, including notably the so-called oyster-catcher, *Hœmatopus longirostris*, and the numerous members of the crane tribe that frequent the oyster-banks at ebb-tide, prey to some extent on the young oyster brood. Next to the borer, however, the greatest amount of injury to the oyster-cultivator's growing crops is probably committed by the innumerable species of crabs that infest the beds and banks.

A destructive agency that has caused great losses to the oyster-growers of New South Wales, and of which there was some suspicion of its having made its appearance among the oysters in Wide Bay, is what has been styled the "Worm Disease." This disease is characterised by the presence, within the oyster-shells, of patches of mud, which are more or less completely covered in by a shelly or membranous re-deposit. One or more small worms, *Leucodore ciliata*, are almost invariably found enclosed within these mud cavities, and from these, through a tubular channel, they maintain a communication with the outside water. This worm is usually credited with the primary origin of the so-called disease; but on the strength of a slight passing acquaintance made with it in New South Wales, and of the facts relating to it that have been published, the author is inclined to believe that the organism is only an accompaniment, and not the cause, of the disease. Mr. Whitelegge, of the Sydney Museum, who has approached the subject from the standpoint of the worms being the originators of the disease, has offered the following remarks, after making investigations concerning its occurrence at the Hawkesbury River:—"The principal home of the worm appears to be on the mud-flats about low water-mark. The oysters from this region, the Hawkesbury, were invariably infected with the worm, particularly those which lay loose on the surface or were partially buried in the mud. Those oysters which were fixed to some solid substance, and elevated ever so little above the mud, were comparatively free from the pest." The foregoing testimony goes far to show that this so-called worm disease is essentially a "dirt disease." It is only in a muddy environment, unsuitable for the healthy growth of the oyster, that it spreads; and that it is the mud, and not the oyster *per se*, that attracts the worm, is demonstrated by the fact that oysters elevated but a few inches above the muddy stratum are relatively free from the affection.

The inference arrived at by the author concerning the occurrence and manifestations of this disease, is that the oyster, through the foulness of its surroundings, draws into its shell cavity, by the ciliary action of its gills, a greater amount of mud than it can get rid of, and that the worm, in its free-swimming embryonic state, being drawn within this cavity by the same ciliary current, settles down with alacrity within so congenial a mud-lined cradle. The worm, *Leucodore ciliata*, under discussion, enjoys an almost cosmopolitan distribution. Its habitat, as recorded in Dr. Johnson's catalogue of non-parasitic worms, in the year 1865, is as follows:—"Found living between seams of slaty rock near low-water mark, and burrowing in the fine soft

mud which lines the fissures." The author has been informed by a well-known Queensland oyster-cultivator, that the same species of worm was noticed by him many years ago, burrowing in the mud-filled crevices of timber-work in Sydney Harbour. The species, like most members of its class, is an essential mud lover, and its natural instincts guide it, in its earliest larval condition, to seek out and establish itself within any appropriate mud-lined crevice.

So extensive have been the depredations of the mud disease with its associated worms in New South Wales, that many of the formerly most productive oyster-grounds of that colony have been practically depleted ; and it is owing to this disease, mainly, that, instead of exporting, that colony is now so largely dependent on Queensland and New Zealand for its supplies. Much anxiety has naturally been manifested to exclude this destructive agency from taking up its abode in Queensland waters, and, having that circumstance in view, the fullest information concerning its probable cause and possible prevention will doubtless prove acceptable. In this direction the views expressed in a lecture upon "Oysters and Oyster Culture in Australia," delivered by the author at the meeting of the Australian Association for the Advancement of Science held at Christchurch, New Zealand, in January, 1891, are herewith recapitulated.

"The rock oyster, *Ostrea glomerata*, affected by the disease, is a species that attains to its maximum development in brackish water, and indeed survives exposure to fresh water immersions, in times of floods that would prove fatal to the so-called mud oyster, *Ostrea edulis*. As a corollary to the brackish water proclivities of *Ostrea glomerata*, its most luxurious development in New South Wales has been high up the riverine estuaries, that so abundantly intersect the coast-line. The Hunter, the Hawkesbury, and the Clarence rivers may be mentioned, not only as the most important of the oyster-growing areas, but also as those in which the worm disease, or, as it may be more correctly termed, the 'mud disease,' has been most prevalent. In my opinion, it is the altered conditions of these rivers, brought about mainly through human agency, that has induced the diseased condition of the oysters, their waters, in fact, being rendered more or less incapable of supporting the mollusc in a healthy state.

"Through the clearance of the land and the establishment of townships and settlements throughout the watersheds of these rivers, the rainfall which in former days fell upon, and was more completely absorbed by, the primeval forests, is now carried quickly away, and emptied by drains and culverts into the watercourses communicating with the rivers. Simultaneously with this augmented discharge of water into the rivers, a vastly larger quantity of sediment is brought down, accompanied by a considerable percentage of organic and chemical pollution, that had no place in the composition of the water under those conditions in which the oysters originally grew and flourished. This greatly augmented accession of flood water, with its accompaniment of sediment and chemical pollution, cannot exert other than a very deleterious influence upon the riverine oyster fisheries.

"A case in point, in which the oysters, formerly growing abundantly many miles up a river's

course, have been gradually pushed farther and farther down towards the sea, through the agencies just described, fell under my personal observation in Tasmania. In the river Tamar, debouching on the northern coast-line of that colony, the mud oyster, *Ostrea edulis,* was originally abundant, from the Heads half-way to the town of Launceston, some forty miles distant. By degrees, as borne testimony to by residents of the district, the oysters have gradually disappeared from the formerly prolific higher portions of that river, known as Whirlpool Reach and the Middle and Eastern Arms. On my first visit to the Tamar estuary, a few oysters were still left in the lowest bay, known as the West Arm, but these, both young and old, were in a dead or dying state, owing chiefly to prolonged immersion in water containing an insufficient amount of saline ingredients, the organic pollution, from the city of Launceston, probably also playing an important part in their destruction. Within a few years after this first visit, oysters were practically extinct in the Western Arm, and no success attended the efforts made to resuscitate the fishery in that district by artificial culture. The last lingering remnants gathered there were in a decidedly unhealthy state, the shells being discoloured and wanting in solidity, and the contained oysters being in the poorest possible condition.

"Should the interpretation here suggested be correct, with relation to the diseased condition of the New South Wales oyster fisheries, it is evident that the prospects are but small of recovering the ground lost to oyster culture in the several districts affected. It will consequently be incumbent on the oyster-growers of that colony, to make the most of the water area left to them where the water is pure and not liable to be invaded by the disease, and, if they are ambitious to regain that position formerly held, in which the colony was independent of supplies from external sources, they will require to turn their attention to the culture of the mollusc on a far more scientific basis than has been hitherto attempted in New South Wales waters."

Concerning the suspected or prospective invasion of the Queensland oyster-beds by this mud disease, with its accompanying parasitic worms, the author is in a position to report that there is, at all events, no evidence to hand of its invasion at the present time. A little while since, there was some suspicion of its having made its appearance in Wide Bay, and a few specimens of oysters which, on being opened, were found to contain a parasitic worm, were submitted for examination. The worm, however, in these solitary instances, was a nereid, representing a different genus than that associated with the New South Wales disease, and had apparently gained access to the shell through a perforation originally made by a boring whelk. There are circumstances which, in the author's opinion, will operate for a long while, and, it is to be trusted, permanently, against the introduction of the disease under notice into Queensland waters. In New South Wales, as previously stated, the oyster fisheries devastated belong entirely to riverine systems which have become much altered in character and polluted by sedimentary deposits, through the clearance of their inland water-sheds. The oyster-grounds of Moreton and Wide Bays, on the other hand, have such near and free communication with the open ocean, that they are not influenced to anything approaching

the same extent by floods from the tributary rivers, from the effects of which they speedily recover.

It is pertinent to mention here that the fears which have been expressed in some quarters lest the disease under notice should be introduced with the worm from New South Wales are, in the author's opinion, altogether groundless. As a matter of fact, Leucodore is already in Moreton Bay; it is of cosmopolitan distribution, and has been obtained by the author among the coral-reefs as far north as Torres Strait. So long as the oyster-banks of Queensland are maintained in a clean and healthy state, the worm is not likely to invade them. So soon, however, as these become choked with foul mud and sedimentary deposits, the conditions will be made favourable for the advent of the worm; and it may most assuredly be expected.

There are one or two directions in which the productive oyster fisheries of Queensland are threatened with injury, and to which it is desirable that attention should be paid. Under existing regulations, what are known as the Government or public oyster reserves are supposed to be retained as breeding centres for the express benefit of the general public, who are permitted to help themselves, without restriction, to such oysters as they can consume on the ground, but are prohibited from carrying them away. This privelege, however, has been abused to such an extent, that on many of the most extensive of these preserves the oysters have been completely stripped, and carried off in a wholesale manner. It is, in the author's opinion, essential, for the continued prosperity of the oyster fisheries of this colony, that judiciously selected areas should be strictly and permanently reserved as nursery or breeding centres, for keeping up the supply of spat. Having regard, also, to the extent that many of the leased grounds and banks are denuded of their oyster crops, without compunction or consideration of future cultivators, it is also highly desirable that a clause should be included in the leases granted, requiring the continual reservation on the ground, or bank, of a certain proportion of breeding oysters, or, at all events, prohibiting their entire removal. With such suggested breeding reserves, efficiently maintained, the Queensland oyster fisheries would be well insured against all risk of the injury through over-depletion that has befallen those of certain of the more southern colonies. At the same time, the foundation would be laid for the development of this important industry, on a more extensive scale than has hitherto been attempted, for which there is a wide field open, more particularly in the direction of canning, and other preserving processes, for the export market.

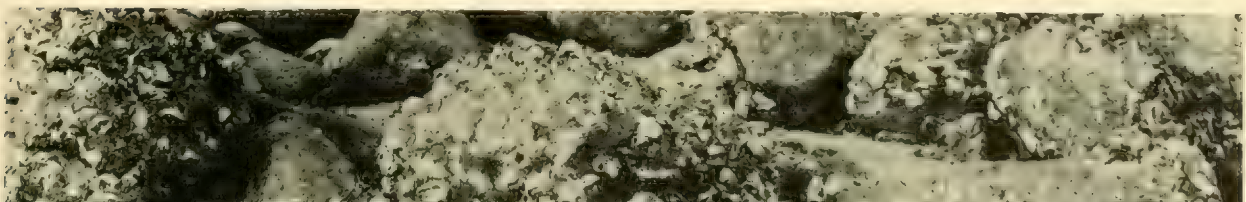
THE EMBRYOLOGY OF THE QUEENSLAND COMMERCIAL OYSTER, *OSTREA GLOMERATA.*

Considerable uncertainty having up to a recent date prevailed concerning the embryological phenomena of the ordinary rock oyster of Queensland and New South Wales, the author devoted some time in the year 1890 to the investigation of this subject. The results of this enquiry were embodied in a paper communicated to the Royal Society of Queensland in February of that year, and from it the following account has been epitomised:—

The researches that have been already conducted by European and American naturalists, with relation to the commercial oysters of the northern hemisphere, have elicited the fact that the fertilisation and development of the oyster brood or spat proceeds in each case upon a distinct plan. In the case of the most familiar European type, *Ostrea edulis*, represented by the far-famed British native, and the variety so extensively cultivated on the coast of France, the propagation of the species is accompanied by a condition in which the oyster is unfit for consumption, and is prohibited to be sold. This is occasioned through the circumstance that the parent oyster nurses or incubates its brood within the pallial or mantle cavity, throughout the early stages of its development, and does not liberate it until the shells of the young oysters are fully formed. An oyster eaten during the later portion of the breeding season appears to be full of sand or grit, this being due to the presence of millions of minute shell-bearing embryos. By oyster dealers at home, two distinct spawning conditions of the oyster are recognised: the one, when the embryos contained within the mantle chamber of the parent are white and colourless, being devoid of shells, is designated the "white sickness." The later stage, when, the shells being formed, a grey or blackish tint is imparted to the entire mass, is known as the "black sickness." The close or spawning season of the ordinary European oyster, *Ostrea edulis*, extends throughout the summer, from May to September, and is popularly defined as coincident with those months in which the letter "r" is absent.

The fecundation of the ova of the European oyster necessarily takes place within the mantle cavity or brood-chambers of the female. The fertilising agent or milt of the male is discharged into the water, and thence it is transferred and brought into contact with the mature ova, by the ciliary currents that exercise the ordinary respiratory, and food-purveying, functions in the female mollusc. This plan of propagation was until within recent years supposed to apply to all descriptions of oysters. Investigations associated with the reproductive phenomena of the American commercial oyster, *Ostrea virginiana*, failed, however, to discover any trace of the brood or spat within the mantle-cavity of the breeding oyster, and it was ultimately demonstrated by Dr. Brooks (1880) that both the ova and milt were simultaneously discharged into the water in their mature condition, and, fertilisation being there effected, that the entire development of the embryo took place independently of the parent. Such being the case, the artificial propagation of the species by the commingling in sea water of the matured sexual elements was considered feasible, and was successfully accomplished by the above-named authority. In the case of the typical European oyster, *Ostrea edulis*, such a method of artificial propagation is not possible, chiefly on account of the fact that the embryos are matured within the brood chambers of the parent in a fluid medium, containing a large proportion of albuminous matter that cannot be artificially produced. Following upon the discovery of Dr. Brooks, in connection with the American oyster, it was demonstrated by M. Bouchon-Brandeley, in the year 1882, that the small Portuguese oyster, *Ostrea angulata* exhibits developmental phenomena which coincide essentially

OYSTER REEF, KEPPEL BAY.



W. Saville-Kent, Photo.

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CORAL-ROCK OYSTERS.

with those of the American species, the ova being similarly discharged into the water, where they are fertilised and developed independently of the parent. The artificial fertilisation of the ova of this species, and the investigation of the more important embryological phases of this Portuguese type, were also successfully carried out by the authority cited.

The oysters of Australia, like those of the northern hemisphere, exhibit two distinct plans of propagation. The commercial form indigenous to Tasmania and Victoria, but now so reduced in numbers by exhaustive fishing as to be scarcely known in the market, cannot be distinguished from the *Ostrea edulis* of European waters, and it is usually associated by naturalists with the same specific title, but is sometimes denominated the variety Angasi. The reproductive phenomena of this oyster have been personally investigated by myself, and were found to coincide precisely with those of its European congener, the embryos in like manner being fertilised and developed within the mantle or pallial cavities of the parent. Similar phenomena have also been found by me to obtain in the closely-allied New Zealand mud oyster, which is also, apparently, a local variety only of the same species.

The most important commercial oyster of Australia is undoubtedly the familiar rock oyster, *Ostrea glomerata,* of which Queensland enjoys the enviable position of producing the largest supplies ; Moreton Bay and Wide Bay alone growing sufficient quantities not only for home consumption but also for exportation to the neighbouring colonies. The method of propagation of this oyster, to which I have paid some attention within the past few weeks, is, I find, in all respects identical with that of the American commercial species, *Ostrea virginiana.* The fertilisation of the ova is brought about by their coming in contact with the milt or sperm cells in the open water, the young embryos being thus cast adrift and thrown upon their own resources from the earliest period of their existence. The artificial propagation of this species by the abstraction of the matured sexual elements, the ova and spermatozoa, and their admixture in a little sea-water, may in consequence be easily effected, and yields a most interesting and instructive embryological study. The method of procedure successfully adopted in accomplishing such artificial propagation, and the more conspicuous metamorphoses through which the embryo passes before assuming the parent form, may be described as follows :—

The aid of a microscope with a magnifying power of about 200 diameters is, in the first instance, indispensable for securing the most satisfactory results. On opening a number of oysters, the cream-coloured, fat-like mass, near the hinge or joint of the bivalve shell, represents the seat of the reproductive elements. Inserting a fine spatula in the midst of this mass, a small portion may be abstracted, and spread out in a drop of sea-water, or in the natural juices of the mollusc, on an ordinary glass slip. Placed under the microscope, the ova of the female will be at once recognised by their ovate or pyriform contour, the separate ova having an average diameter of the $\frac{1}{500}$th part of an inch. The male elements, or spermatozoa, when abstracted and similarly treated, present a widely different aspect. Its separate elements are so diminutive as to

appear as minute granules only, under the same magnification ; and a considerably higher amplification is requisite to reveal their individual structure. This is then shown to consist of a minute bulbous head and an exceedingly slender flexible hair-like tail, the proportions between the two being much the same as that of the head and shank of an ordinary pin. After a little experience, it will be found easy to distinguish the comparatively coarse granular ova from the cloudy masses of spermatozoa, when placed on the glass slip, with the aid only of an ordinary pocket lens, or even with the unassisted vision. The assistance of the microscope is, however, desirable to insure the most favourable results, and is altogether indispensable for tracing the further development of the embryos. In many instances it will be found that the ova or spermatozoa are not sufficiently matured, or, in the case of oysters purchased in the market, that they have become so deteriorated by isolation from their native element for too long a period, as to be incapable of effecting reproduction. All conditions being satisfactory, the ova under the microscope should present a clean and evenly-rounded outline, while the vitality of the spermatozoa should be manifested by their active oscillating and vibratory movements. Should the sperm cells fail to exhibit this vitality, their admixture with the ova will prove of no avail.

In practice it will be found that the number of oysters containing the female elements, or ova, is greatly in excess of those producing the milt, or sperm cells, the average proportion of the sexes in many hundred examples recently examined being one male to six or seven females. The small quantity of milt that is required to fertilise a very large number of ova satisfactorily illustrates Nature's economy in this direction. No peculiarities of external structure exist, so far as I have been able to ascertain, that serve for distinguishing between the male and female oyster before being opened. Healthily matured milt and ova having been successfully obtained, portions of each, the ova predominating, may be mixed in a watch-glass half full of sea-water, and well stirred together. The ova, being heavier, will soon sink to the bottom, leaving the spermatozoa diffused, as a cloud, through the water. After an interval of ten minutes the top water may be poured off or withdrawn with a pipette and fresh supplied, and any fragments of lacerated tissue or tufts of immature milt must be removed with a needle; these, if left, will decay, and pollute the water. The pouring off process should be repeated until the top water is quite clear and the bottom consists entirely of fertilised ova. If a small drop of water containing the mingled milt and ova is examined under the microscope at short intervals, some remarkable changes in the form and structure of the ova will soon be observed.

Almost immediately following upon the admixture of the two elements it will be found that the sperm cells are adhering in numbers by their dilated heads to the delicate capsular investment, or vitelline membrane, of the ova, and that many of them, through the vigorous vibrations of their tail-like prolongations, will have a distinct oscillatory motion. It may also be observed that through the aperture of the narrower end of the capsule, known as the micropyle, several of the sperm cells have effected an entrance, and have been brought into direct contact with the body of the

ovum. The fusion between the two elements that then takes place is not easy to trace, but the results arising from the union are speedily manifested. The ovum, prior to fertilisation, was distinguished by the presence of a central clear area with a contained nodular structure, the two representing what are distinguished technically by the titles of the "germinal vesicle" and "germinal spot," or the "nucleus" and "nucleolus." Shortly after fertilisation, the substance of the ovum becomes opaquely granular throughout, and the germinal vesicle is no longer visible. Within the second hour, a small globular protuberance will have made its appearance at the broader end of the ovum, and opposite to the micropyle. This is the so-called directive, or polar, cell. Quickly following upon this, the entire body-mass of the ovum becomes furrowed, or constricted, across the centre, and each half is seen to contain a central nucleus. The upper half, associated with the polar cell, now divides itself into two equal parts. These again split into four and next into eight, the aspect of the ovum or embryo, as it may now be correctly termed, at about the end of the third hour being that of a number of small coherent cells, superimposed symmetrically on the top of a large basal cell.

This condition of development represents an important phase in the life-history of the embryo oyster. There are now present all the essential elements out of which the perfect animal will be built up. Out of the smaller superincumbent cells all the investing membranes, tactile organs, and essential animal structures will be fashioned, and they are consequently distinguished as the formative cells. The large basal cell, on the other hand, represents the nutritive or vegetative element, out of which will be constructed the stomach, the alimentary tract, "and its appended glands." Within from four to six hours, the smaller, or formative, cells have so increased and spread as to completely enclose the large nutritive cell, and which in its turn now divides up and lays the foundation of the alimentary tract. Fine hair-like cilia are at this stage developed upon the external surface of the embryo, and by means of these it progresses through the water in an irregular rotatory manner. The polar cell, which up to this stage had occupied a conspicuous position, now breaks loose and disappears. The metamorphoses from this point progress more slowly. From the tenth to about the fifteenth hour the general shape of the embryo is somewhat kidney, or turban, shaped, it having a slight depression on one side. This represents what is known to biologists as the gastrula stage, a structural phase which has been found to be represented in some period of the development history of almost every known form of animal life higher than the unicellular protozoa. In its most typical condition, this gastrula embryo consists of a cup-shaped body composed of two single cell layers, the outer one being built up of the animal or formative cells, and the inner one out of the nutritive or vegetative cells. The distinctive appellations of the "epiblast" and "hypoblast" are commonly applied by biologists to these outer and inner cell layers.

After passing the "gastrula" stage, development towards the typical organisation of the parent oyster proceeds apace. The central cavity representing the stomach opens out by an anterior and

a posterior passage and apertures, which correspond respectively with the throat and mouth, and the intestine and vent. The shells make their appearance on the surface of the body, and gradually increase in size until they enclose the entire animal. Simultaneously with these metamorphoses a disc, covered with powerful vibratile cilia, has developed at the anterior extremity, with the assistance of which the embryo oyster can propel itself vigorously through the water. "As the shells grow larger and heavier, the little oyster becomes less capable of sustaining itself in the water, and finally sinks to the bottom. This is a crucial epoch in the mollusc's existence. Should it settle upon a rock, shell, or other clean, hard substance, it attaches itself to it, and its life is assured; but should it, on the contrary, light upon soft mud, sand, or other material to which it cannot adhere, it inevitably perishes. The proportion of young oysters that find a secure anchorage, in comparison with the vast numbers that are devoured, or become literally lost at sea, is necessarily infinitesimal."

The time taken by the embryo of the Australian oyster to pass through the series of metamorphoses enumerated, and to arrive at the attached or sedentary state, has been found by the author, under favourable conditions, to average four days, two out of these elapsing before the shells become conspicuously apparent.

Within from eighteen months to three years from the date of its birth, the embryo becomes a marketable oyster, measuring the standard two inches in its longest diameter. Such, however, is the precocity of the species that oyster brood, not more than three months old, and but half an inch in diameter, was found, in association with the foregoing embryological investigations, to be laden with fully-matured ova and milt.

Some further experiments that were conducted, in the course of the foregoing enquiry, with the object of ascertaining the influence of water of varying density, as in time of floods, upon this embryonic oyster brood, have been referred to on page 258. Among the practical results suggested, in connection with the foregoing embryological data, is the feasibility of fertilising, and artificially propagating, the embryos of *Ostrea glomerata*, in numbers largely in excess of what is accomplished in a state of nature. In Europe, where the demand is so much in excess of the supply, and the market prices are consequently high, and also in America, much attention is being given to the problem of thus successfully cultivating oysters from their earliest embryonic state. By such time as this supply and demand shall be equivalently balanced in the Australian market, a resort to methods of artificial fertilisation and propagation may be found profitable.

DETAILS OF AREAS RESERVED OR LEASED FOR OYSTER CULTURE IN QUEENSLAND WATERS, WITH RETURN OF QUANTITIES AND VALUE OF OYSTERS IMPORTED.

The areas devoted to the industry of oyster culture in Queensland waters fall under the three

separate categories of dredge-sections, oyster-banks, and oyster-grounds. Under the first-named title are included extensive water areas producing dredge oysters only, and not extending shorewards above the limit of low-water mark. These areas are leased by auction, for terms of fourteen years, to the highest bidder. The waters of Moreton Bay were originally subdivided into forty-two such sections. The value of certain of the more productive of these sections may be gauged, by the fact that the rental realised for one of the more important ones, when recently put up to public auction, was no less than £1,000 per annum. Within the term "oyster-banks" are included all oyster-bearing banks, reefs, or other areas, comprised within the limits of high-water mark and two feet below the lowest ebb. For these areas, licenses are issued at the uniform rate of £5, for any such bank not exceeding thirty acres in extent. The total number of banks marked off, according to the latest returns, is in Moreton Bay 347, and in Wide Bay 167. In the Rockhampton district, including Rodd Harbour, Port Curtis, and Keppel Bay, between forty and fifty similar banks have been licensed or are under survey. The subdivisions termed "oyster-grounds" have been recently defined to take the place of "dredge-sections," for the purpose of including areas producing oysters either in collectively deep or shallow water, or from high-water mark on one side to the same limit on the opposite side, of any given area. These oyster-grounds are, as in the case of the dredge-sections, let by auction on leases of fourteen years' duration to the highest bidder.

The license-fees payable upon the boats occupied in the oyster trade, as affixed by the Oyster Act of the year 1886, are as follows: £1 annually for every boat so employed that does not exceed three tons, and a further sum of 10s. for every ton or part of a ton above the measure ment. The license-fee charged for every person engaged as master, servant, or assistant in dredging, collecting, or carrying away oysters, for sale, is 10s. per annum.

Return, Relative to the Quantity and Value of Oysters Exported, from Brisbane and Maryborough.

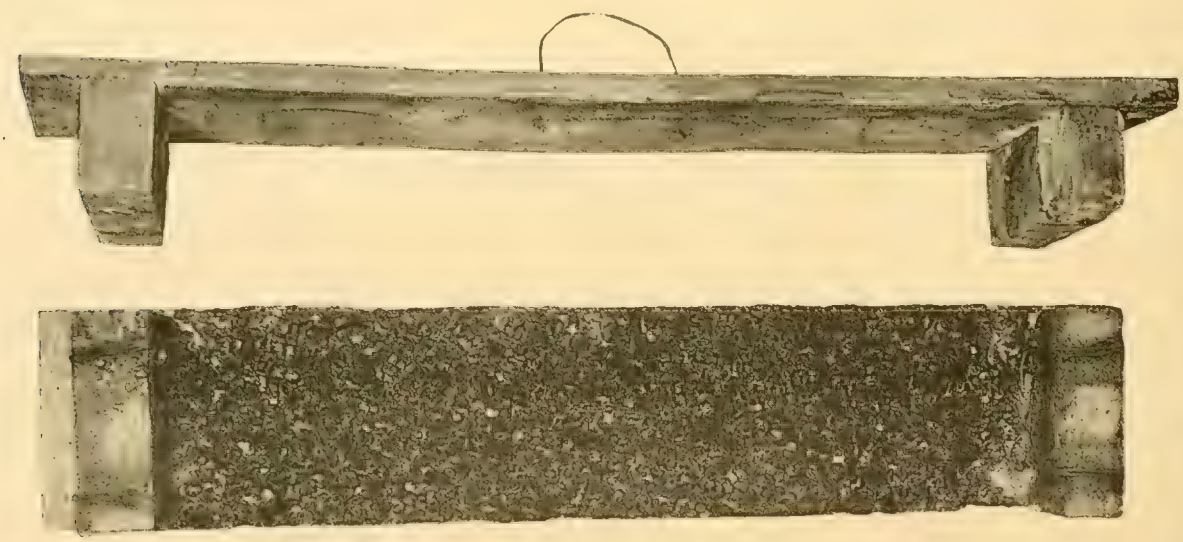
BRISBANE.

Year.	No. of Bags.	Value.	Year.	No. of Bags.	Value.
		£			£
1870	4,523	1,644	1881	7,559	6,153
1871	5,127	1,625	1882	9,953	9,074
1872	4,060	1,427	1883	7,878	7,342
1873	3,036	768	1884	8,256	8,475
1874	3,912	1,704	1885	8,076	8,094
1875	5,349	2,622	1886	7,512	8,533
1876	6,648	2,792	1887	7,167	8,240
1877	2,736	1,639	1888	6,191	7,616
1878	1,790	1,227	1889	9,791	13,368
1879	3,793	2,729	1890 (six months) ...	4,890	5,696
1880	5,293	3,475			

MARYBOROUGH.

Year.	No. of Bags	Value.	Year.	No. of Bags.	Value.
		£			£
1887	1,692	1,967	1889	1,914	3,677
1888	1,990	3,326	1890 (six months) ...	1,300	3,174

The foregoing table, showing the quantities and value of the oysters exported from Moreton and Wide Bays, has been reproduced from Mr. C. L. Fison's Report for the year 1890, as Inspector of Oyster Fisheries, Moreton Bay district. The figures relating to the Brisbane exports, extending over a period of twenty years, furnish a practical illustration of the steadily increasing value and extent of this highly important fishery.



CHAPTER VIII.

FOOD AND FANCY FISHES.

QUEENSLAND possesses a fish fauna remarkable both for the abundance of its species and for the structural variety of its constituents. All told, the number of combined marine and fresh-water species, authentically recorded up to date, falls but little short of 900. In other words, it embraces two-thirds of the entire known marine and fresh-water fish fauna of the Australian continent. Out of the foregoing total number, over 300 species may be classified as of more or less value for human food, leaving a balance of between 500 and 600 to which, for the most part, a scientific interest, only, can so far be attributed. The numbers given will very probably in both instances be materially augmented by extended investigation, as the marine and fluviatile waters of Queensland are, as yet, by no means exhaustively explored.

The classified list attached as an appendix to this volume will suffice to furnish the reader with an approximate idea of the extent and variety of the Queensland fish fauna, so far as it relates to the prominent edible species. The task of its exhaustive description would necessarily involve the compilation of a volume as large as, or larger than, the present one; and it is, consequently, only possible in the present chapter to give a general sketch of its leading features, concentrating more special attention on those forms that are most noteworthy, either for their economic utility, or their scientific, structural, or ornate features. The term Barrier district, if here interpreted somewhat liberally, or in such manner as to include the rivers that debouch upon its precincts, will afford the opportunity of including in this sketch a brief notice of certain remarkable species that either possess few, or no known existing, allies in other parts of the world.

Limiting attention more particularly, in the first instance, to the species that are of economic value, it may be generally stated that the fish fauna of Queensland, compared with that of the more southern Australian colonies, including New South Wales, Victoria, and Tasmania, together with New Zealand, presents many distinctive features. The fish of its northern districts more especially are characteristic of what is known to zoologists as the Indo-Pacific, or Oriental region. Among other distinctions, it may be observed that the much-esteemed group of the trumpeters (genus Latris), which forms so important a factor in the fish markets of Tasmania, Victoria, and

New Zealand, while sparingly represented in New South Wales, is altogether absent from Queensland. Almost equally conspicuous by their absence are the rapacious shoal fishes known as barracutas, which contribute so extensively to the fish supplies of the southernmost colonies, including the common barracuta, *Thyrsites atun*, of Victoria, Tasmania, and New Zealand; the king-fish of Tasmania, *T. Solandri;* and the rarer frost-fish of New Zealand, *Lepidopus caudatus*. Two representatives of the same family, however, popularly known as hairtails, *Trichiurus savala* and *T. haumela*, are rarely recorded from Queensland waters; but they nowhere occur in sufficient numbers to constitute, as in the preceding instances, important fisheries. The peculiar group of so-called sea perches or morwongs of the Sydney markets—genus Chilodactylus, belonging properly to the same family as the trumpeters, the Cirrhitidæ—while including several important food species in the southern colonies, is in Queensland represented by but one comparatively small and unimportant type, *C. gibbosus*. An additional important group that is apparently altogether unrepresented in Queensland waters is that of the true cod fishes, or gadidæ. One species, *Pseudophycis barbatus*, the common rock-cod of the Melbourne and Hobart fish markets, has to be included among the most important food-fishes of the southernmost colonies, and an allied variety, *P. breviusculus*, are not unfrequently imported to Brisbane, in the smoked form, from New Zealand. Another member of the same family, *Lotella marginata*, or the beardie of the Sydney market, occurs, though not abundantly, in Port Jackson, but has not hitherto been recorded from Queensland. The northern rivers of Tasmania and the southern ones of Victoria similarly produce a somewhat remarkable fresh-water cod, *Gadopsis marmoratus*, the black-fish of the colonists, which is most excellent eating.

An enumeration may now be made of those forms that pertain essentially to Queensland, and that either already enter into, or are capable of utilisation for, the food supply of the community. As a guide to the identification of some of the more prominent forms described, the photographic illustrations reproduced in Plates XLIII. to XLVIII., and the two Chromo-lithographic plates Nos. XV. and XVI., may prove of service, and will be referred to in the order of their succession.

Following the order adopted in the appended classified list, the first group to demand attention is that of the typical perch family, or percidæ. This group, which is world-wide in its distribution, is represented in Queensland waters by upwards of seventy species of a size and quality that render them valuable for food purposes, and by about an equal number which, on account of their smaller size or comparative rarity, are excluded from consideration in the same category. Among the foremost on the list with relation to dimensions, and estimation from a culinary point of view, is the so-called giant perch, *Lates calcarifer*, Bl. (Plate XLIII., Fig. 1). This magnificent species, which frequents the coast-line and estuaries, from Keppel Bay northwards, attains to a length of four or five feet, and may weigh over 50 lb. In common with *Ceratodus Forsteri* and *Osteoglossum Leichardti*, this monster perch is locally known by the title of

CULTIVATED OYSTER BANK, MORETON BAY.

W. Saville-Kent, Photo.

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WHELK-OYSTER BANK, MORETON BAY.

the Barramunda, a name that it would appear is somewhat indiscriminately applied by the aborigines to all large fresh-water fish of superior gastronomic properties. Another local name, by which this fish is known in the Pioneer River district, is that of the "Palmer." The Queensland giant perch has a somewhat extensive distribution, being met with also on the coast-line and in the rivers of India. Distinguished by the local title of the "Cockup," it is one of the most highly-esteemed fish sold in the Calcutta market, its flesh being remarkably light and well-flavoured. The large Queensland species, described by MacLeay and Allport under the name of *Pseudolates cavifrons,* is now regarded as identical with *Lates calcarifer.* An allied, but much smaller species, *Lates colonorum,* Gth., representing one of the most abundant market fish of Victoria, and there commonly known as the Gippsland perch, while extending to New South Wales, does not so far appear to have been met with in Queensland waters. *Psammoperca Waigiensis,* C. & Val., is an allied percoid of economic value, belonging more essentially to the inter-tropical seaboard of Queensland, and extending thence along the North Australian coast-line. *Enoplosus armatus* of White (the old wife, or bastard dorey, of the Melbourne and Sydney markets) has been recorded from Moreton Bay, but is not of great value as a food-fish.

The sea perches included in the genus Serranus are represented in Queensland waters by upwards of twenty species, the majority being inhabitants of the inter-tropical zone. They are for the most part brilliantly coloured and ornamented with spots, crossbands, or longitudinal stripes. Nearly all are edible, more or less esteemed for the table ; and they in many instances attain to a large size. Their capture is most readily effected by line fishing. Several of the species common to Queensland waters, including *Serranus hexagonatus,* C. & Val., have been taken by the author at Port Darwin. A common Barrier Reef species, *Serranus crapao,* C. & V., coloured a dark olive-green, with rust-red spots, is represented by Plate XLIII., Fig. 3. In another abundant reef form apparently identical with *Serranus ouatalibi,* C. & V., the ground colour is reddish-brown, decorated throughout with brilliant blue, black-edged, spots. One of the Serrani obtained in Moreton Bay, *S. geometricus,* De V., is popularly known as the "surveyor," while a number of others are indiscriminately, though wrongly, classified as rock-cod.

The several genera, Plectropoma, Priacanthus, Genyoroge, Diploprion, Pristipoma, Mesoprion, and Glaucosoma, all closely allied to Serranus, contain collectively some twenty species of value for human food. Among those with which popular names have been already associated may be mentioned the red bass, *Mesoprion superbis,* Cast. ; the spotted wirrah, *Pristipoma maculatum,* Bl. ; the hussar, *Genyoroge amabilis,* De V., the queen fish, *G. regia,* De V., and the pink *G. rubicauda,* De V. Also the epaulette fish, *Glaucosoma scapulare,* Ram., known to Sydney fishermen by the title of the pearl perch. The javelin fish, *Pristipoma hasta,* which grows to a considerable size, and is much esteemed for food, occurs plentifully northwards from Rockingham Bay, and has been collected by the author in connection with the recent surveying cruise of H.M.S. *Myrmidon* along the northern coast, as far west as Port Darwin and Cambridge Gulf. A representation of

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this fish, which is also known locally as the Queensland trumpeter, with reference to the grunting noise it makes on being taken from the water, is delineated in Plate XLIV., Fig. 1.

Among the generic groups of the perch family inhabiting Australian waters, most important from a commercial point of view, is that of Oligorus. It includes the so-called Murray cod, *O. Macquariensis*, C. & Val., which grows to a weight of from 80 to 100 lbs. or more, and furnishes the materials for an extensive trade, in connection more especially with the Melbourne market. This valuable species is distributed through all the colonies watered by the Murray River and its connecting streams, Queensland receiving its most considerable share from the Darling River and its tributaries, in the neighbourhood of Goondiwindi. It has recently been shown also to inhabit the Mary River and other streams, debouching on the eastern coast-line. Two huge representatives of the same genus, viz., *Oligorus goliath*, De V., and *O. terræ-reginæ*, Ram., popularly known by the name of gropers, inhabit salt water and are not unfrequently taken with hook and line on the "schnapper" grounds in Moreton Bay; they are more abundant, however, among the coral-reefs, and in the river estuaries, further north. The two last-named species are stated to grow to a weight of four or five cwt.; while examples have been taken in the Brisbane River more than six feet long and weighing over 160 lb.

An illustration of the better-known Barrier Reef form, the Queensland groper, *Oligorus terræ-reginæ*, is given in Plate XLIII., Fig. 5. Evidence was obtained by the author that this species of groper enters the Norman River from the Gulf of Carpentaria, possibly for spawning purposes, regularly in the month of May; and at that time the fishermen have consequently to abandon stake-net fishing, or run the risk of having their nets destroyed by these weighty fish. Some idea respecting the customary food of gropers may be formed from the circumstance that the stomach of an example caught in the Pioneer River, near Mackay, was found to contain several large crabs, each of which weighed upwards of four pounds. A third known marine species of Oligorus, *O. gigas*, Owen, represents one of the most important food fishes of New Zealand, and is locally known to the Maories by the name of the hapiku. A large fish closely related to Oligorus, which has been recently discovered in Queensland waters, is *Homalogrystes luctuosus*, De V. It is locally known by the title of the purple groper. A second species of the same genus, *H. Güntheri*, A. & Mcl., has been recorded from Torres Strait. The many varieties of so-called Murray perch and Murray bream—genera Ctenolates, Murrayia, Riverina, and Therapon—which are forwarded in large quantities from the central districts of the Murray River system to the Melbourne market, in company with the Murray cod, are conterminous in distribution with that species, and have been recorded from the Darling River and other Queensland tributaries. The genus Therapon, which includes *T. Richardsoni*, Cast., the silver perch of the Murray River, is represented by as many as twenty Queensland species, all more or less esteemed for food, which are variously distributed among the rivers debouching upon the eastern and northern coast-lines. Several allied species of perch referable to the genus Dules also inhabit the rivers of the eastern watershed, one species, *D. Haswelli*, Mcl., being taken in the Brisbane River.

The genus Diagramma includes a group of sea-perches, represented by six species belonging chiefly to the tropical districts of the Queensland seaboard. All the known species have a favourable reputation as food fishes, and some attain to the considerable length of three or four feet. An excellent table fish belonging to the perch family, occasionally taken in Moreton Bay and further north, but having apparently no vernacular name, is known technically by the title of *Lobotes auctorum*, Gth. The species is remarkable for its extensive range, it having been recorded from Australia, the East Indies, and the Atlantic coast-lines of tropical and temperate America. It inhabits both salt and brackish water, and attains to a length of two feet. In shape, excepting for the absence of filamentous rays to the ventral fins, it somewhat resembles the celebrated gourami, *Osphromenus olfax*, Hardw., of Java, Borneo, and other islands of the East Indian Archipelago. In allusion to its dark sombre hue, this fish has been associated by the author with the title of the "Queensland dusky perch." An extensive genus of the sea perches that requires mentioning is that of Gerres. It includes two edible Queensland species, which are popularly classified among the breams; one is the *Gerres filamentosus*, C. & Val., sometimes taken in Moreton Bay, but more abundant northwards, and the other the so-called deep pouter, or deep-bellied bream, *G. profundus*, Mcl., recorded from Cardwell and the inter-tropical coast-line generally.

A handsome representative of the perch family, *Genyoroge Sebæ*, C. & V., commonly taken throughout the Barrier district as far south as Port Denison, and also in the Gulf of Carpentaria, is popularly known to Bowen fishermen as the "government bream," and has received its distinctive title with reference to the broad-arrow-like mark, with the point directed vertically, which decorates each side. It grows to a weight of several pounds, is much esteemed for the table, and has been forwarded in some quantities, in a smoked condition, from Sweer's Island in the "Gulf" to the Normanton and Croydon markets. When alive in the water, or freshly taken from the sea, the ground colour of this fish is nearly white, with pale pink edges to the scales, the characteristic broad-arrow-like bands being a bright red. On removal from its native element, these tints quickly darken, the white ground turning to red, and the arrow-shaped mark almost to black. Among the smaller edible species of the perch family, a small fish, *Synagris tæniopterus*, C. & V., marked with longitudinal bands of pale rose and lemon-yellow, is very commonly caught with hand-lines from the ships, when anchored for the night, in their course through the reefs up and down the coast. It possesses a delicacy of flavour somewhat resembling that of the European red mullet, and when cooked after the same manner, in buttered paper, is much esteemed for the table. The gold perch is the popular title by which this species is commonly known in North Queensland waters. Two other small fish, allied to the form last described, are not unfrequently taken with the line, on the pearl-shelling grounds in the Torres Strait, and are regarded as a welcome addition to the table. Both species are remarkable for the long filamentous appendage that is developed from the upper lobe of the caudal fin; the larger of the two, *Dentex filifer*, Cast., may be distinguished as the long-tailed perch; the smaller species, *Pentapus*

paradiseus, Gth., which is the more common, being known among the pearl-shell fishermen as the China or Paradise fish. Neither of these two last-named fish appears to exceed half-a-pound in weight. The colours of the two species correspond closely with one another, and consist of a silvery ground tint, variegated with pale pink, blue, and yellow, longitudinal stripes.

The family of the Squamipinnes, or scale-finned fishes, is distinguished, as the name implies, by the fact that the scales are developed more or less extensively upon the surfaces of the dorsal and anal fins, the line of demarcation between these fins and the body, in consequence of this peculiarity, being very frequently almost completely obliterated. The numerous representatives of this group are, for the most part, of small size and brilliantly coloured, and frequenters chiefly of the inter-tropical waters and coral-reefs. There are, however, some half-a-dozen species taken on the Queensland coast that have to be classified among the food fishes. These include three species of Scatophagus, having some external resemblance to certain of the trevallies, or horse mackerels; one of these, *S. ætate-varians*, De V., being the so-called banded dorey of the Queensland coast-line, is represented by Fig. 4 of Plate XLVII. A species of Scorpis, *S. vinosa*, A. & Mcl., allied to *S. æquipinnis*, Rich., the so-called sweep of the Sydney fishermen; and *Drepane punctata*, C. & Val., a handsome compressed silvery fish, esteemed for food and distributed throughout the north-eastern, northern, and north-western coast-lines of the Australian continent, belong to the same family group. The vernacular name of this last-named fish, given to the author at Port Darwin, by the Chinese fishermen, was that of chonghu. On the Queensland coast-line it is commonly known by the title of the spotted dorey, and under the last-named designation is photographically illustrated in Plate XLIV., Fig. 3.

A somewhat remarkable species belonging to the family of the Squamipinnes, common in the estuary of the Endeavour and other native rivers, and which is particularly abundant in the Norman River and adjacent lagoons, is known at Normanton as the "spotted bream." Its correct scientific name is *Toxotes jaculator*, and it is elsewhere distinguished by the title of the rifle or archer-fish, with reference to its singular method of securing its food. This consists chiefly of the flies that settle on the surface of the water-plants in its haunts, which it adroitly captures by discharging a small jet of water at them from its mouth. So accurate is the fish's aim, that the fly is often hit and precipitated into the water, where it is immediately seized, from a distance of two or three feet. An illustration of this singular fish is given on Plate XLV., Fig. 4. It is fair eating, but rarely exceeds a length of ten or twelve inches, or a weight of one or two pounds.

The family of the red mullets, or Mullidæ, whose members are characterised by their predominating red or rosy hues, and the two filamentous appendages or barbels that depend from their lower lip, comprises fish of high commercial value. It includes, in European waters, the typical red mullet, *Mullus surmuletus*, L., for which, in classic ages, fabulous sums were frequently paid, and which, up to the present day, maintains its reputation as one of the most *récherché* and delicate of table fishes. Several closely allied species are indigenous to Australia; the Victorian red

mullet, *Upeneus porosus*, C. & Val., being greatly esteemed, and realising a high price in the Melbourne fish market. As many as half-a-dozen varieties of red mullet belonging to the genera Upenoides, Mulloides, and Upeneus, have been recorded from Queensland waters, though none so far appear to have been taken in sufficient quantities, or of sufficiently large size, to prove of commercial value. This group of fishes, however, is one that demands resort to methods of capture essentially distinct from those that have hitherto been practised on this coast-line, and the introduction of these would probably effect substantial additions to the existing fish supply.

The sea-bream family, Sparidæ, already occupies an important position in connection with the Brisbane fish market. It includes the celebrated schnapper *Pagrusu nicolor*, C. & Val., regarded by many as the finest food fish, excepting the Tasmanian trumpeter, inhabiting Australian waters. Its capture in Queensland, however, has hitherto been accomplished chiefly by private fishing parties, though it is, no doubt, a species which would well repay systematic capture by professional fishermen, for public consumption. The most northern point on the Queensland coast-line in which the true schnapper is caught in any quantity, is that of the neighbourhoods of Flat- and Round-top Islands, off Mackay; but it is also reported as occurring, sparingly, in the vicinity of Bowen, Port Denison. At the last-named station the author has taken a species of schnapper, *Pagrus spinifer*, illustrated by Plate XLIV., Fig. 2, which is new to the Australian fish fauna, and better known as an Indian species. A third species of Pagrus, decorated with bright blue spots, after the manner of the immature or so-called "Squire," condition of the ordinary schnapper, has been likewise derived from this locality, and has also been reported from Thursday Island. It would appear to be identical with *Pagrus major*, Temm., hitherto associated only with the west coast of Australia. The common silver breams, or "tarwhines," of the Sydney market are represented by three Queensland species. These are *Chrysophrys australis*, Gth., *C. sarba*, Fsk., and *C. hasta*, Bl. All are valuable food fishes, the two first-named contributing extensively to the fish supply of Brisbane, while the third species, *C. hasta*, is limited in its distribution to the estuaries and coast-line of the inter-tropical zone. Of the black breams, or sweeps proper, as they are called in the southern colonies, genus Girella, two species, *G. carbonaria*, De V., and *G. mentalis*, De V., have been recorded from Moreton Bay, while a third form, *G. simplex*, Rich., common to New South Wales and Victoria, has been taken near Murray Island. "Black-fish" is the local name that has hitherto been chiefly applied to these bream in Queensland. The members of the bream family referable to the genus Lethrinus, belong essentially to the Indo-Pacific region; they are most abundant in the north and north-eastern coast-line of Queensland, being there represented by as many as twelve species, some of which attain to a length of two or three feet. They all possess the characteristic "molar" dentition of the ordinary sea breams, but are usually more gaily coloured, being variously ornamented with longitudinal stripes or vertical streaks or spots. They are good table fish, readily taken with hook and line, and might doubtless be captured in large quantities with the aid of set nets. One typical species,

Lethrinus imperialis, De V., having brilliant vermilion tints, is popularly named the Emperor. Another representative of the genus, the so-called "Pig-faced bream" of the Wide Bay district, *Lethrinus rostratus*, C. & V., or a near ally, is represented on Plate XLV., Fig. 3. Its colours in life are a golden-brown, varied by a scarlet band along the outer edge of the dorsal fin, while stripes of a similar colour occur round the eye and at the bases of the pectoral and ventral fins.

The family of the Scorpænidæ, embracing the red rock-cods, or rock-gurnets, is represented in Queensland waters by numerous species. Six of these belong to the genus *Centropogon*, and are closely allied to *C. australis*, White, the typical rock-gurnet of the Melbourne market. Four others are referable to the genus Scorpæna, and include among their number the Sydney red rock-cods, *Scorpæna cruenta* and *S. cardinalis*, Rich., the latter species being also known here by the name of the cardinal. All the members of this genus are more or less esteemed for food. They are essentially ground or "bottom" fishes, easily recognised by their large spinous heads; while many of the species are further distinguished by the presence of skinny tentacles and appendages, developed chiefly on the head, but also more or less extensively on other portions of the surface of the body.

A fish, belonging to the family of the Scorpænidæ, whose appearance does not recommend it for the table, but which is nevertheless so highly prized by the more wealthy Chinese residents of Cooktown, that they willingly buy it from their fellow-countrymen for no less a sum than 2s. 6d. per lb., is illustrated by Plate XLVII., Fig. 1. This is the so-called Stone-fish, *Synancidium horridum*, L., and, in addition to its forbidding aspect, it bears an evil reputation on account of the painful nature of the wounds it is capable of inflicting. The bases of the anterior dorsal spines are surrounded by glands secreting a milky fluid, which apparently, as in the allied European forms known as the weevers or sting-fish, *Trachinus vipera* and *T. draco*, possess the properties of a highly irritant poison. The flesh of the stone-fish, when cooked, has a peculiar short, fibrous, texture, combined with a flavour much resembling that of crab. Its habits are exceedingly sluggish, and as it lies hidden among stones or dead coral *débris*, it so closely corresponds with these in aspect, as to be only with difficulty detected. The Stone-fish rarely exceeds a length of from twelve to fifteen inches, or a weight of from one to two pounds. In the illustration given, two young specimens which were found in close proximity to the adult have been simultaneously photographed.

The small family group of the Teuthididæ, represented by the single genus Teuthis, includes some half-a-dozen Queensland species which are more or less esteemed for food. In consequence of their somewhat resembling the ordinary trevallies, Carangidæ, in shape, they are usually associated with them by the uninitiated. In this manner, three of the commoner Queensland species, *Teuthis flava*, De V., *T. albo-punctata*, Schl., and *T. nebulosa*, Q. & G., are popularly known as the yellow, the spotted, and the clouded trevally—this last-named fish being also identical with the black trevally of the Sydney market. The construction of the fins of this

BARRIER REEF SHELLS ON SPONGE TABLE.

W. Saville-Kent, Photo. Waterlow & Sons Limited.

BARRIER REEF SHELLS ARTISTICALLY UTILISED.

genus is, however, altogether distinct from that which obtains in the true trevallies, and is in fact unique of its class. There is a much larger series of bony spines in the dorsal and anal fins—(viz., thirteen in the former and seven in the latter) as compared with the eight, at the most, of the dorsal and the three of the anal in the Carangidæ; while the ventral fin of Teuthis presents the anomalous peculiarity of having a spinous ray on both its outer and inner margin. The dorsal and other spines of Teuthis are exceedingly sharp, and capable of inflicting wounds of such severity, that it would appear that some specific form of virus secreted by the fish is communicated to them. In the case of the black trevally, *T. nebulosa*, more particularly, it is recommended that all the spinous fins should be removed with a pair of large scissors, immediately the fish is caught. With reference to their defensive armature, this small group may be appropriately distinguished by the title of the spined-trevallies.

The tassel-fishes, family Polynemidæ, constitute a somewhat remarkable group, most abundantly represented in the vicinity of the estuaries of muddy tropical rivers. Its members are readily distinguished by the peculiar filamentous processes which are developed at the bases of the pectoral fins, and which, in some species, considerably exceed the body of the fish in length. Four or five species, referable to the single genus Polynemus, have been recorded from the Queensland coast-line. One most excellent table species, *Polynemus tetradactylus*, which, on account of its external shape and the pink tint of its flesh when cooked, is known locally as the Cooktown salmon, is represented by Plate XLVI., Fig. 2. This fish is taken plentifully in the estuary of the Endeavour River; and, while commonly averaging ten or twelve pounds' weight, it may grow to a much larger size. Another notable form, Sheridan's tassel-fish, *Polynemus Sheridani*, Mcl., abundant at some seasons at the mouth of the Mary and Burnet rivers, is stated to grow to a weight of no less than one hundred pounds, and is locally known as the Mary-, or Burnet-, River king-fish. Both this and other larger varieties of the same genus are highly esteemed for food, while from allied, and in some instances identical, Indian species, an excellent quality of isinglass is obtained, which forms an important article of commerce. Others, again, as noted by the author at Palmerston, Port Darwin, are extensively dried for future consumption. This is undoubtedly a group of fishes to which more attention might be profitably directed. *Polynemus indicus*, Shaw, *P. macrochir* Gth., and *P. cæcus*, Mcl. are among the important forms, in addition to the two above mentioned, that are found in Queensland waters. The species last-named is popularly known as the blind tassel-fish, with reference to the circumstance that the eyes, though normally developed, are covered by a dense filmy skin, which must apparently greatly impair their function. The natural thick-water habitat of these fish would imply a relatively diminished exercise of the visual sense; but this deficiency would appear to be compensated for, by the specialised tactile appendages developed in connection with the pectoral fins. A species new to science, having seven filamentous rays, five of which exceed the body in length, was obtained by the author in the estuary of the

Ord River, Cambridge Gulf, in association with the surveying cruise of H.M.S. *Myrmidon*. It has been named *Polynemus Verekeri*, in compliment to Captain the Hon. H. P. Foley Vereker, then in command of that ship, to whom the author was indebted for much hospitality, and unparalleled opportunities of investigating the fish-fauna of that little-known locality.

The Sciænidæ, or jew-fishes, are represented in Queensland by several species, referable chiefly to the genus Corvina, the most familiar and valuable commercial form being *C. axillaris*, De V.,—the jew-fish of the Brisbane market,—which attains to a length of three or four feet, with a weight of 50 lb. and upwards. An allied species, *Sciæna antarctica*, Cast., regarded by some authorities as identical with the maigre, *S. aquila*, of the European seas, bears the same title of jew-fish in New South Wales; but it is known to the Victorian fishermen as the king-fish. Although not yet recorded from Queensland waters, it very probably extends its migrations to at least the southern limits of the Queensland coast. It grows to a length of six feet, and is very highly esteemed for the table. A smaller species of Corvina, *C. canina*, De V., that may weigh, however, several pounds, is plentiful at certain seasons in the Brisbane River, and affords excellent sport with the line. It is one of the many forms popularly known as perch. *Corvina albida*, C. & Val., is a large representative of the same genus that has been recorded from the Norman River, North Queensland. A species of Umbrina, *U. Mulleri*, belonging also to the Sciænidæ, and described by Klunzinger, has been obtained from the Queensland coast.

The family of the barracutas, Trichiuridæ, includes fish characterised by their much-compressed elongate bodies. They are of rapacious habits, and usually range the seas in extensive shoals. One of the most familiar species, *Thyrsites atun*, C. & Val., representing the common barracuta of Victoria, Tasmania, and New Zealand, occupies a very important position with relation to the fish markets of those colonies; and while hitherto unobserved alive in Queensland waters, it is not unfrequently imported to Brisbane in the smoked condition, from New Zealand. Two allied fish, referable to the genus Trichiurus, *T. savala*, C. & Val., and *T. haumela*, Bl., have been contributed to the Queensland museum, and may not improbably be found in certain localities, and at certain seasons, in sufficient abundance to be of commercial value. The last-named of these two types, *Trichiurus haumela*, grows to a length of five or six feet, and occasionally appears in shoals on the coast of New South Wales. The European representative of the same genus, *Trichiurus lepturus*, L., is popularly known as the hairtail. Other closely-allied Australian forms are the frost fish of New Zealand, *Lepidopus caudatus*, White, and the Tasmanian king-fish, *Thyrsites Solandri*, C. & Val.; both very highly esteemed for the table. The representatives of this family are most effectively captured by means of hooks and lines trailed astern, with the vessel going at a good speed. The apparatus known as a jig, by which the common species of barracuta is most extensively taken in Tasmania and New Zealand, consists of a square piece of cedar wood, about an inch thick and five or six inches long, to which one or two barbless hooks are firmly

fastened. In place of a hook, a nail is frequently driven through the wood at an acute angle; and bait in the form of a piece of scarlet cloth or fresh hide may be added, but is not essential. At Warrnambool, on the Victorian coast, the half-grown fish, about two feet long, are most extensively captured with the ordinary spoon-bait. In either instance the apparatus may be either trailed through the water by a long line, or, as is more general, attached by a yard or so of line to a staff five or six feet in length, by means of which the fish, immediately they seize the hook, are lifted bodily out of the water over the sides of the boat. A Queensland fish, locally known by the name of barracuta, is, as hereafter shown, a sea-pike belonging to the genus Sphyræna.

The trevallies proper are included with the scads, or horse-mackerels, in the family of the Carangidæ. The typical genus Caranx embraces several very important commercial species. The silver trevally, *Caranx Georgianus*, C. & Val., of the southern colonies, grows to a weight of from 10 to 12 lb., and undoubtedly represents one of the most delicate and finest-flavoured fish in Australian waters. An allied species, *Caranx nobilis*, Mcl., represented by Plate XLVII., Fig. 3, obtained from Moreton Bay and throughout the eastern coast-line, is commonly known to fishermen as the white trevally. It grows to a length of two feet or more. No less than twelve other species of the same genus are recorded from Queensland waters, a large proportion of them pertaining to the northern or inter-tropical coast-line. The only type among these that appears, so far, to have received a popular title, is the so-called diamond fish, *Caranx gallus*, L., that is met with in some abundance northwards from Port Denison and is very delicate eating. A coloured representation of this and also of another form, *Caranx radiatus*, common throughout the Barrier region, remarkable for the fringe-like development of its fin rays, is given in Chromo plate XVI., Figs. 1 & 2. The trevally group, from a commercial and gastronomic point of view, has not yet received the attention which it worthily commands. Two forms closely allied to the genus Caranx are *Chorinemus toloo*, C. & Val., and *C. lysan*, Forsk., the latter from the district of Cape York and the former extending thence as far south as Moreton Bay. The last-named species, of which an illustration is given in Plate XLVI., Fig. 4, is distinguished at Thursday Island by the title of the queen fish. The subdivision of the posterior margin of the dorsal fin into penicellated tufts or finlets, together with the minute spicule-like character of the scales, which are buried in the skin, serve to distinguish the genus Chorinemus from that of Caranx.

Included in the same family of the Carangidæ is the large and valuable food fish known in the Queensland, Victorian, and Tasmanian fish markets as the yellow-tail, *Seriola grandis*, Cast. The Sydney fishermen apply the name of the king fish to a species that is in every essential respect identical, which is known to science as *Seriola Lalandii*, C. & Val. The common horse-mackerel, *Trachurus declivis*, C. & Val., is also associated with the name of the yellow-tail in the Sydney market. The true yellow-tail, Seriola, now under discussion, is not unfrequently taken in Moreton Bay. It is a "school" fish growing to a weight of from 50 to 60 lb., readily taken with hook and line, or, as in some localities, with the harpoon. It is much esteemed for

the table. Another New South Wales representative of the genus Seriola, whose range probably extends to Queensland waters, is *S. hippos*, Gth.; this species is known to the Sydney fishermen by the title of the Samson fish.

The tailor or skip-jack, *Temnodon saltator*, Bl., known also locally as the diarbi and pombah, is another member of the Carangidæ closely allied to Seriola. Like that, it associates in shoals; it grows to a weight of about 17 lb., and affords excellent sport, though, at the same time, owing to the extreme sharpness of its closely-set teeth, it is exceedingly destructive to lines and fishing nets. While it must be regarded as one of the most representative fish of Moreton Bay, the species is remarkable for its extensive distribution. It occurs not only throughout the Australian coasts, but also on both sides of the Atlantic, and furnishes, under the name of the "blue fish," one of the most important fisheries of the United States. The tailor fish is an excellent table variety, and is in best season during the winter months. In hot weather, the flesh undergoes decomposition very rapidly. A photographic representation of this cosmopolitan species is given in Plate XLIII., Fig. 4. A genus of the Carangidæ, represented by as many as twelve species in Queensland waters, though chiefly in the northern coast-line, is that of the Equula, which may be typified by *E. edentata*, Bl. In form, its members somewhat resemble the bastard dorey, genus Cyttus, having, in common with that type, a deeply-compressed body, an anteriorly elevated dorsal fin, and a highly protractile mouth. The species, while in all instances edible, do not attain to large dimensions. The bat fish, *Psettus argenteus*, L., popularly relegated to the breams, is another representative of the Carangidæ, commonly taken from Moreton Bay northwards, which is reckoned among the food-fishes of both this colony and of New South Wales. The popular name given to it is apparently associated with the somewhat wing-shaped development of the dorsal and anal fins.

A larger species of bat fish, identical with the *Stromateus niger*, Bl. of the Indian seas (and, excepting for the elongate pectoral fin, much resembling in shape the common bat or diamond fish of Moreton Bay), although not hitherto associated with an Australian habitat, is occasionally captured from the lightships in northern waters, and also in the neighbourhood of Cairns and Townsville, where it is known respectively by the titles of blue skate and holibut. It is most excellent eating, grows to a length of two feet, with a weight of many pounds, and is of a dark blue slate-colour when taken freshly from the water. A photographically reproduced illustration of this valuable food fish, which, according to Dr. Day, appears at certain seasons in shoals off the Malabar coast, is given in Fig. 4 of Plate XLIV. The genus Platax, belonging to the sáme family of the Carangidæ, contains two good edible species which, in MacLeay's "Australian Fishes," are associated respectively with a Port Darwin and a New Guinea habitat. The first of these, *Platax orbicularis*, Forsk., is tolerably plentiful at Bowen, and thence northward to Thursday Island. Its common name is the silver dorey; it is also an excellent table fish, and grows to a weight of seven or eight pounds. *Platax teira*, Forsk., the second species, which rarely exceeds one pound in weight, is remarkable for

the abnormal elongation of the dorsal and anal fins, which have won for it, at Cairns, the title of the butterfly fish ; elsewhere it is known as the banded dorey.

The family of the true mackerels, or Scombridæ, is admitted by all ichthyologists to represent one of the four families of fishes most useful to man, the remaining three being that of the herrings, Clupeidæ, the true cods, Gadidæ, and the salmon family, Salmonidæ. The high importance pertaining to this group in European and American waters does not, however, extend to the Australian seas. At the same time, a species that is scarcely to be distinguished from the Mediterranean mackerel, *Scomber pneumatophorus*, De la Roche, but which has been named *S. antarcticus*, Cast., is occasionally taken in Queensland waters, and has been observed making its way northwards in vast shoals, along the New South Wales coast-line. These mackerel are further said to visit Sydney harbour three or four times in the course of the year, but generally when young and of small size. It is not improbable, from the observed direction of their migrations, that they attain to their mature condition off the Queensland coast, in which event the species might yield material for an important fishing industry. Two other members of the mackerel family that occur abundantly in Queensland waters are a species of bonito, *Thynnus McCoyi*, Cast., and a large so-called horse-mackerel, *Cybium Commersoni*, Lac., which is better known in the northern districts by the title of the king fish. This last-named form, delineated in Plate XLVI., Fig. 1, represents one of the species which, in common with the yellow-tail and the bonito, may be obtained by trolling a baited line astern from a sailing boat or steamer, if not making more than six or seven knots. A fish of this variety, weighing about 30 lb., if boiled like salmon, is one of the most delicious eating of Australian fishes. This, and other typical representatives of the mackerel family, are easily recognised by their sharply-pointed conical bodies, adapted for rapid movement through the water, and by the presence of a number of minute finlets, which occupy the position of the ordinary dorsal and anal fins of other species.

A somewhat abnormal member of the mackerel tribe, modified in the direction of the sucking fish, Echeneis, is known by the technical title of *Elacate niger*. An example of this species, about two feet long, was supplied, among other food varieties, from the Claremont lightship, for the table of the Chinese steamer *Tsinan*, during the author's passage up the Queensland coast in the year 1888, and proved most excellent eating. It differs from the typical mackerels in the absence of finlets, in the very flattened form of the head and body, and in the asymmetry of the tail; in both last-named respects it somewhat resembles the sea-catfishes of the genus Arius. A second specimen of this fish has been more recently forwarded to the author from Bowen, Port Denison, by Mr. A. W. Hodgkinson.

"Whitings," of the family Trachinidæ and genus Sillago, furnish an important contingent to the Queensland fish supply. Three species, including the trumpeter whiting, *S. bassensis*, C. & Val. ;

the sand whiting, *S. ciliata*, C. & Val. ; and the Sydney whiting, *S. maculata*, Q. & G., frequent Moreton Bay, and extend southward to New South Wales; while a fourth species, *S. gracilis*, Mcl., is obtained in Torres Strait, and is distributed throughout the northern Australian coast-line. These "whitings"—not to be confounded with the European fish bearing the same name, which are members of the cod family or Gadidæ—deservedly occupy a front rank among the Australian food fishes, their flesh being very white, exceedingly delicate, and easily digestible. The largest specimens rarely exceed a length of eighteen inches, with an accompanying weight of from a pound and a-half to two pounds.

The family of the Cottidæ, which includes the flatheads and gurnards, yields here, as in the adjacent colonies, a substantial contribution to the general fish supply. The most abundant and familiar type is the common flathead, *Platycephalus fuscus*, C. & Val., identical with the ordinary variety of the Sydney market, but better known in Melbourne as the rock flathead. In addition to this, some half-a-dozen other species have been obtained on the Queensland coast. One of the commonest northern forms, *Platycephalus Staigeri*, is represented by Plate XLIII., Fig. 6. This genus, however, is nowhere in Queensland waters represented so abundantly as it is in the southern coast-line of Australia, and where, more especially on the Tasmanian and Victorian coast, toujours flathead and nothing but flathead, becomes a severe tax on the patience of the amateur line-fisherman. The typical gurnards, including the genera Trigla and Lepidotrigla, are conspicuous for their abnormally developed wing-shaped pectoral fins and for the leg-like form and function of the three anterior pectoral rays, with the aid of which these fish literally perambulate the sea bottom. Two species, representing both of the above-named genera, have been obtained from Queensland waters ; they are the so-called flying gurnard, *Trigla polyommata*, Rich., and the butterfly gurnard, *Lepidotrigla Vergeri*, Temp. The gurnards in the European seas occupy an important position from a commercial standpoint, and are among the leading fish that are most abundantly taken with the trawl net. The few experiments with the trawl that have so far been made in the neighbourhood of Moreton Bay, while demonstrating the existence of the above-named fish in some abundance, have failed hitherto to reveal their presence in quantities, or of size sufficient for commercial utility. Further systematic investigations of a like nature, and in different directions, may not improbably result in the discovery of localities in which these fish may be obtained of larger size and in remunerative numbers.

Under the family title of the Gobiidæ, have to be included some two or three species of the genus Eleotris, which, while not of sufficient importance to rank among the commercial species, may be utilised as food. Over twenty species are indigenous to Queensland, the majority being denizens of fresh water; the greater portion of them are of small and insignificant size, but some few, such as *Eleotris aporos*, Blk., and *E. crescens*, De V., may attain a foot or more in length, with a weight of over one pound. Loter is the popular title by which these fish are most generally known. They are chiefly allied to the small marine fish known as gobies, genus Gobius, and which

are also represented by numerous species in Queensland waters. None of them, however, are of economic account.

The sea-pikes, family Sphyrænidæ, are represented by several Queensland species. The common Moreton Bay variety, *Sphyræna obtusata*, C. & Val., is identical with the ordinary pike of the Sydney fish market; while a more recently discovered species, *S. dentatus*, De V., has been obtained from the same locality. A third species, *Sphyræna langsar*, Blk., frequents the northern coast-line; and there is one other variety with a recorded North Australian and South New Guinea habitat, whose distribution, it may be anticipated, extends to Queensland waters. One species, apparently identical with either the *Sphyræna Forsteri* or *S. Commersoni*, of Cuvier and Valenciennes, attains to a height of three or four feet, with an accompanying weight of thirty pounds and upwards. In the neighbourhood of Thursday Island the species is popularly associated with the title of the "barracuta," though, as explained on a previous page, it belongs to a family group distinct from that of the true barracutas—Thysitidæ, of the Southern Australian seas. A large Sphyræna, probably identical with the northern species, is occasionally taken as far south as Moreton Bay, and is locally associated with the name of "dingo," with reference to its formidable array of teeth. The sea-pikes are highly esteemed for the table, the abundant Victorian species, *Sphyræna Novæ-Hollandiæ*, Gth., being extensively taken for the market in Port Phillip and Western Port Bay, with baited hooks, or spoon-baits, trailed astern of the fishing boats sailing under full canvas.

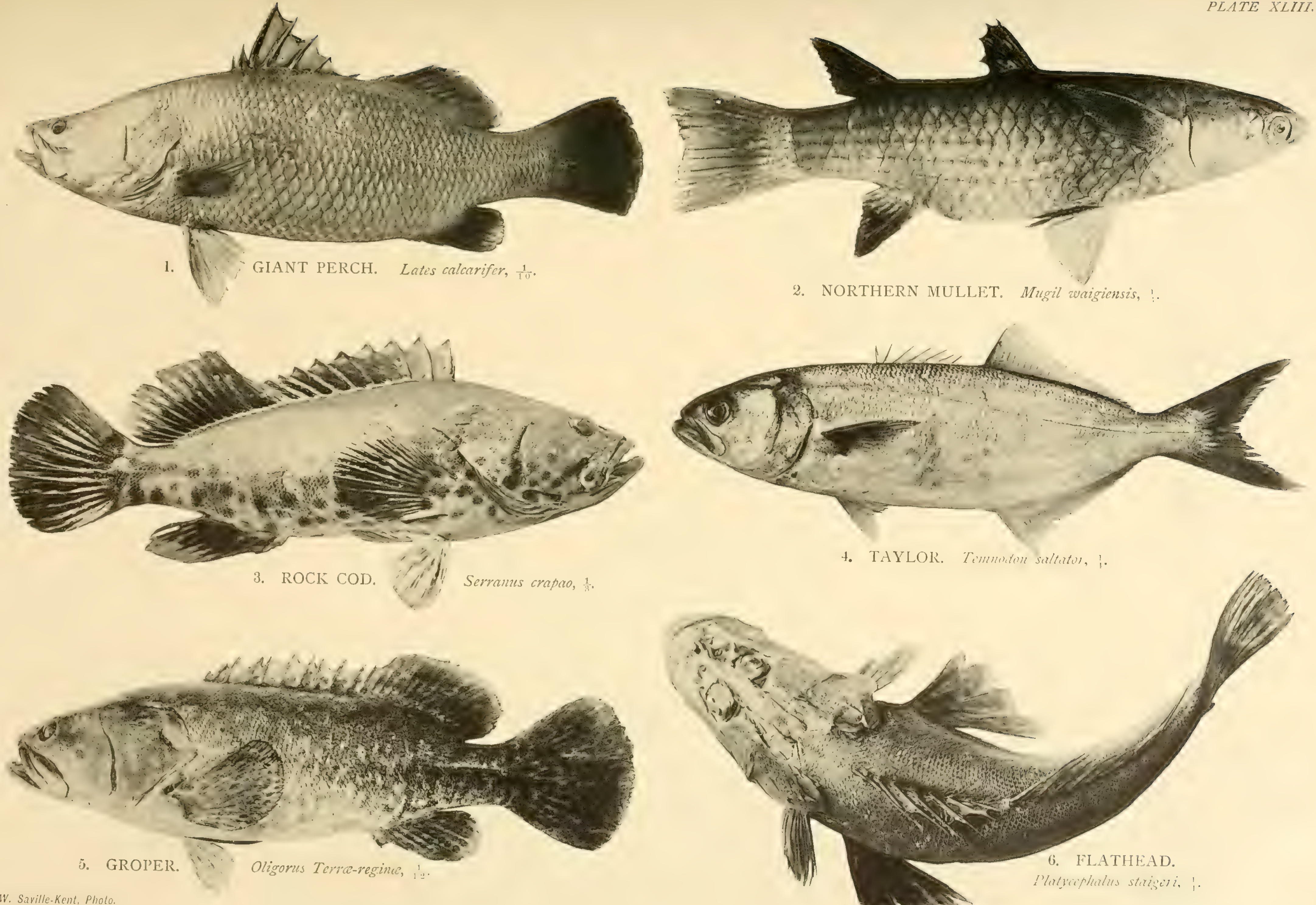
The Atherinidæ, or sand smelts, are shoal fish of small size, numbering in Queensland waters as many as nine species. In shape and dimensions they much resemble sprats, and might, as in the case of the European species, be turned to similar economic use. The Queensland varieties are referable to the two genera, Atherina and Atherinicthys. One of the commonest species, *Atherina pinguis*, Lac., abundant also in New South Wales, is known to the Sydney fishermen as the hardy-head.

The family of the grey mullets, Mugilidæ, represents one of the most important groups, if not *the* most important, of the Queensland food fishes, its varieties yielding collectively a permanent market supply throughout the year. No less than twelve species of this important family, all with one exception referable to the typical genus Mugil, are included in the Queensland fish fauna. Some of these have a high reputation for the table, while others, in consequence of their greater abundance, are more valued for commercial purposes. Taken in the order of their economic importance, precedence is almost universally conceded to the sea mullet, a magnificent fish growing to a weight of from 10 to 12 lb. and upwards. This species arrives in Moreton Bay about the last week in April, continues plentiful till the middle of July, and by August has passed away to the North. Some uncertainty has hitherto been associated with the correct technical identification of this species. As known on the New South Wales coast, it has been usually regarded as a distinct form, upon which Castelnau bestowed the title of *Mugil grandis*. There can, however, be but

little doubt that it represents the mature condition only of *Mugil dobula*, Gth. ; a species that is better known in its half-grown or immature state, in Brisbane as the mangrove mullet, in the Sydney market as the hard-gut mullet, and finally in Victoria and Tasmania as the sand mullet. A personal acquaintance with this fish under these separate titles in the several colonies named has confirmed the author in the opinion here expressed. How far north the sea mullet continues its migrations is a subject that has not yet been satisfactorily decided. The author has, however, met with the species among the coral islets of the Barrier, to the north of Cooktown, in the month of September. The northern mullet, *Mugil waigiensis*, Q. & G., the fantail mullet, *M. compressus*, Gth., *Mugil nasutus*, *M. splendens*, *M. peronii*, *M. longimanus*, and half-a-dozen other species whose names are recorded in the supplementary list, are indigenous to Queensland waters, and all are of more or less commercial value. A member of the genus Myxus, *M. elongatus*, Gth., which differs from Mugil in the possession of fine teeth in the upper jaw, is also a native of Queensland. It, however, rarely measures a foot in length, and is but little esteemed for food. The canning for future use, and for export, of the super-abundant supplies of grey mullet, has been successfully inaugurated in the adjacent Colony of New South Wales, and is worthy of attention in Queensland. The mangrove- or sea-mullet, *Mugil dobula*, is apparently the species most easily accessible and best adapted for this purpose.

The small family group of the Fistularidæ, customarily intercalated between the mullets and the Labridæ, is represented in Queensland waters by a species, *Fistularia serrata*, Cuv., which is not unfrequently included among the many varieties supplied to the Cooktown market. It has the elongate cylindrical shape of a garfish, but possesses a remarkably long tubular snout, of which the small mouth occupies the anterior termination only, while an attenuate thread-like filament is developed from the centre of the tail. In life, the colours are somewhat brilliant, consisting of an olive-green ground, variegated with ultramarine-blue stripes and spots. It grows to a length of two or three feet and is good eating, but it is not sufficiently abundant to become a common article of diet. While more abundant in the northern waters, this species has been obtained by the author among the coral lagoons of Lady Elliot Island, the most southern true coral island in the Great Barrier system; and it is also occasionally captured in Moreton Bay. A representation of this singular form, popularly known as the tobacco-pipe fish, is given on Plate XLV., Fig. 5.

The family of the Labridæ, embracing the brilliant-hued wrasses and parrot fishes, does not include many species that are customarily placed on the market. One exceptional species, however, the so-called blue groper of the Sydney market, *Cossyphus Gouldii*, Rich., attains to a weight of thirty pounds, and takes rank among the most esteemed food fishes of New South Wales. Two allied species, *Cossyphus latro* and *C. aurifer*, De V., have been reported from Moreton Bay. The genus Odax, typified by the so-called "stranger" of the Sydney and Melbourne fish markets, is likewise represented by a Queensland species, that has been described by De



1. GIANT PERCH. *Lates calcarifer*, $\frac{1}{10}$.

2. NORTHERN MULLET. *Mugil waigiensis*, $\frac{1}{4}$.

3. ROCK COD. *Serranus crapao*, $\frac{1}{3}$.

4. TAYLOR. *Temnodon saltator*, $\frac{1}{4}$.

5. GROPER. *Oligorus Terræ-reginæ*, $\frac{1}{12}$.

6. FLATHEAD. *Platycephalus staigeri*, $\frac{1}{4}$.

W. Saville-Kent, Photo.

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BARRIER REEF FISHES.

Vis under the title of *Odax nebulosus.* The majority of the Labridæ are associated in Queensland waters with the coral banks and groves of the Great Barrier system, where they vie in colour with the hues of the living polyps among which they roam. Chromo plate No. XV. is exclusively and No. XVI. is, in great measure, devoted to the illustration of some of the more remarkably tinted of the innumerable Barrier species ; but the delineations, notwithstanding the brilliance of the pigments used, fail to do justice to the marvellous hues of the living fish. Among this series, all the forms represented in Chromo plate XV. are wholesome eating. The species, *Pseudoscarus rivulatus,* represented by the lowermost figures, Nos. 4 and 5 in this plate, is particularly so ; and as these fishes may attain to a weight of more than five pounds, they contribute substantially, where abundant, to the fisherman's commissariat. This "Parrot fish" is essentially gregarious, and is often left in shoals of a score or more in the coral lagoons, such as that depicted in Plate IX. of the phototype series, when the tide is down. To stand up to your knees, or higher, in water, with such a shoal of magnificent fish swimming round you, is an experience worthy of a journey to the tropics. It is, however, like a dream of paradise, liable to be rudely interrupted ; your "native" attendants, most probably, wading in after you with their spears, and dealing wholesale slaughter.

The disparity of colours between the two fish represented by Figs. 4 and 5 of Chromo plate XV. is such, that they might be reasonably supposed to delineate two distinct varieties. That they, however, only represent the two sexes of a single species, was abundantly proved by their invariable association in the same shoal, supplemented by the fact that the separate sexual elements were, on dissection, found to be restricted to fish of each respective tint. An almost parallel distinction of sexual coloration obtains, it may be mentioned, among fishes, belonging to the same family, the Labridæ, that are indigenous to the British seas. Thus, the male of the Cuckoo Wrass, *Labrus mixtus,* notable for its brilliant blue and orange tints, was for long held to be entirely separate from its altogether distinctly coloured mate, and the latter is accordingly figured in the older standard works on British Fishes under the title of the Three-spotted Wrass, *Labrus trimaculatus.* It may be remarked of the Parrot fish Pseudoscarus, now under notice, that, as seen in the water, the females appear from a little distance (and more particularly as seen swimming in the surf) to be an almost intense grass-green throughout, while the males, in like manner, appear more completely suffused with their ground colour of turquoise-blue.

The rapidity with which the colours of the gorgeously-tinted parrot fishes vanish when taken from the water is deplorable to witness ; and hence it is that the ostensible life-colours recorded in association with their technical descriptions in scientific text-books, entirely fail to convey an idea of their living hues. The magnificent species *Cheilinus fasciatus,* represented by Fig. 3 of Chromo plate XV., resplendent in life with a livery of scarlet, black, and softer greys, is described in Day's "Fishes of India" as "yellowish, with dark or black bands," the description being apparently that of a spirit-preserved example. The specimen here figured and coloured

from life was captured by Mr. John Davis, the Mayor of Cooktown, with hook and line, in the vicinity of Turtle Reef, off Cape Bedford ; this is its first record as a denizen of Australian waters, the Red and Indian Seas being hitherto alone associated with its area of distribution.

The genus Chærops, represented by the variegated green, blue, and yellow parrot fish in Fig. 2 immediately above the Chinus, furnishes several tropical Australian species, that are esteemed for food by the pearl-shell fishers and others having avocations in the neighbourhood of the coral reefs. As its characteristic tints and fin formula (D 13, 8, A 3, 11) differ, so far as has been possible to ascertain, from those of any previously described type, it may be regarded as a new species. It having been caught in Port Denison by Mr. A. W. Hodgkinson, to whom the author is indebted for much assistance in investigating the fish-fauna of that district, it is associated in this volume with the title of *Chærops Hodgkinsonii.* The projecting "incisors" of the upper and the "canine" teeth of the lower jaw, coloured in life a brilliant emerald-green, are very conspicuous features in this species.

The orange-banded parrot fish *Xiphochilus fasciatus*, illustrated by Fig. 1 in Chromo plate XV., is a rare species, that has hitherto been obtained only from the neighbourhood of Cape York, and was originally described from this locality by Dr. Günther, Keeper of the Zoological Department of the British Museum, in the Proceedings of the Zoological Society for the year 1867. The specimen here figured was taken with a line by Dr. W. G. K. Barnes, R.N., of H.M.S. *Rambler*, off Adolphus Island at the entrance to Torres Strait, in the vicinity of the scene of the *Quetta* wreck. It is desirable to mention that in the reproduction from the author's original water-colour drawing of this fish, the projection of the upper lip has been somewhat exaggerated.

Two very beautiful parrot fishes, of almost too small dimensions to be of use for food, are represented by Figs. 13 and 14 of Chromo plate XVI. They both belong to the genus Julis, the upper one being apparently identical with *Julis lunaris*, Lin., not hitherto associated with any Australian habitat. The lower one would seem to be an undescribed species ; and, with reference to the intense cerulean hue of the lower surface of its body, it is here associated with the title of *Julis cyano-ventor*. The examples of both these species of Julis were obtained on a reef in the neighbourhood of Rocky Island, off Cape Flattery, and were captured by carefully lifting out of the water, and breaking open, the growing clumps of a branching species of Porites, allied to *P. furcata*. Such submerged colony-stocks of growing coral are citadels of refuge when the tide is down, which yield, if successfully besieged, a rich harvest of small fish and other marine animals.

The "ling" of the Southern Australian Colonies, *Genypterus australis*, Cast., is apparently not represented in Queensland waters, its place being taken here by *Congrogadus subducens*, Rich., a fish bearing the same popular title, associated with a somewhat analogous external aspect, and which is also referable to the same family of the Ophidiidæ.

The important family of the flat fishes, or Pleuronectidæ, includes a considerable number of Queensland representatives ; none of them, however, as known up to within a recent date, attain

to a sufficient size, or occur in sufficient abundance, to occupy an important position in the public food supply. Not improbably, however, the more systematic exploration of the coast-line, with the aid of the trawl and other apparatus, may lead to the discovery of banks on which these excellent food fishes may be obtained of larger size and in remunerative quantities. Among other forms hitherto known may be mentioned the Queensland flounder, *Pleuronectes Mortoniensis*, De V.; the Fitzroy sole, *Synaptura Fitzroyensis*, De. V.; the black sole, *S. nigra*, Mcl.; the lemon sole, *Plagusia unicolor*, Mcl.; the tongue sole, *P. notata*, De. V.; and the peacock sole, *Pardachirus pavoninus*, Lacp. Another small species of sole, *Solea heterorhina*, Blk., has been obtained by the author from Thursday Island, not previously recorded from Australian waters, but included in the fish fauna of India. The single specimen obtained was of small size, not exceeding eight inches in length, and was remarkable for its brilliant colour; a light buff general ground was ornamented with delicate black scribblings, while a narrow band of pale blue extended throughout each fin-border. A delineation of this fish is given in Chromo plate XVI., Fig. 5.

A Pleuronectid, new to Australia, and that attains to considerable dimensions, has been very recently discovered by the author in the waters of Northern Queensland, two individuals having been taken with the seine in the Endeavour River estuary. The species referred to has been identified with an Indian form, *Psettodes erumei*, Bl., and is illustrated by Plate XLVI., Fig. 5. It most nearly resembles in its shape, dental armature, and predaceous habits, the halibut or holibut of the North Atlantic. The specimen figured measured twenty inches in length; and, while struggling in the meshes of the seine net in which it was captured, seized and half gorged a mullet nearly one foot long. The second specimen taken was found to be such excellent eating, that it may possibly prove desirable, at some future date, to attempt the artificial propagation and extended acclimatisation of the species. It represents the finest member of its tribe yet taken in Australian waters; and filling, as it does, the position occupied in the European seas by the highly-esteemed turbot, brill, and holibut, it would undoubtedly command a high price in the market.

It is a well-known biological fact that all the flat fishes, or Pleuronectidæ, commence their existence as perfectly symmetrical fishes, with their eyes on opposite sides of the head and their jaws perfectly symmetrical. In association with their habit of resting on one side, their fins not being strong enough to support them vertically, the eye on the under or ground surface has a tendency to grow towards the light, and it pushes its way round to the light-exposed side, carrying with it the surrounding framework of the skull. Thus it is that our ordinary soles, turbot, and flounders are found to possess such an otherwise inexplicably wry-faced physiognomy. The genus Psettodes, represented by the single known species here figured, is of considerable scientific interest in this connection, since it more completely retains the bilaterally symmetrical character of ordinary fishes than any other known

Pleuronectid. The jaws are almost equally developed, the eyes are as often found on the right-side as on the left, and the fish swims frequently, it is recorded, in a vertical position. Having regard to the formidable prehensile teeth of Psettodes and some few other genera, as compared with the feeble, almost rudimentary, dentition of Solea and its allies, and taking into consideration the circumstance that while the integument in the majority of species is clothed with ctenoid scales, in some few others, such as the Turbot, these scales are replaced by bony tubercles, the question arises whether the Pleuronectid group, as now recognised, may not embrace the convergently modified members of several originally distinct ancestral types.

The catfish tribe, family Siluridæ, is represented in Queensland waters by several edible species; but, on account of their usually uninviting aspect, combined with the possession of pungent spines with which they can inflict exceedingly painful and even dangerous wounds, they are not held in general estimation. The most familiar type, commonly sold in the markets of Victoria and New South Wales, is the tandan, *Copidoglanis tandanus*, Mitch. It grows to a length of two feet or more, and is plentiful in the Murray River and its tributary Queensland streams; it also occurs in the Fitzroy. The flesh of the tandan is very rich and well flavoured, and has been compared with that of the English eel. *Copidoglanis lœvis* and *C. labrosus*, De V., are two other forms of the same genus that have been reported from the Queensland rivers. Several varieties of sea catfishes belonging to the genus Arius are abundant in Moreton Bay and in other parts of the coast, some of them, such as *Arius thalassinus*, attaining to a considerable size. The so-called eel-catfishes or cat-fish eels, locally known as Jew-fishes, are also represented by several species of the genus Plotosus. Some of these inhabit salt and others fresh water, and all are more or less available for food purposes. An allied genus, Neosilurus, has representatives at Rockhampton and in the rivers of Northern Queensland.

Saurida argentea, illustrated by Plate XLVI., Fig. 3, is a species of fish which, in its general shape and size, and in its possession of a small "dead" or "adipose" fin, bears some resemblance to the European smelt, Osmerus. It occurs in some abundance at Cooktown, and has also been obtained by the author at Townsville and Bowen. It, as a matter of fact, belongs to the family group of the Scopelidæ, and is nearly related to the Indian *Harpodon neherens*, which in its dried state constitutes the celebrated "Bummaloe" or "Bombay Duck" of commerce, and is held in much repute as a condiment for curries. The species now under notice, with which the title of "Queensland Bummaloe" or "Queensland Smelt" may be appropriately associated, is excellent eating; and, suitably prepared, it might compete favourably for a position in the world's markets beside its Indian congener. Illustrations of this species submitted by the author to Rockhampton fishermen, were recognised by them as a fish called the "Shandy."

The family of the garfishes, Scombresocidæ, occupies an important position in relation to the food supply of the Australian colonies. The most familiar forms of garfishes, belonging to the

genus Hemirhamphus, are comparatively small elongate fish, rarely extending a foot in length, and distinguished by the beak-like prolongation of their lower jaw. They frequent the coasts and estuaries in large shoals, and are ranked among the most esteemed and delicate fish for the table. As many as five species of garfish have been recorded from Queensland waters. One of these, *Hemirhamphus intermedius*, Cast., is identical with the form commonly sold in the markets of Victoria, Tasmania, and New South Wales. Another of the species, taken in Moreton Bay, is the so-called snub-nosed gar, *Hemirhamphus argenteus*, Benn., remarkable for the circumstance that the beak is reduced to an almost rudimentary condition. In an allied genus, *Arrhamphus sclerolepis*, Gth., also taken in Moreton Bay, but more plentiful farther north, the beak has altogether disappeared. One of the largest species of the genus Hemirhamphus, *H. far*, Forsk., illustrated on Plate XLVII., Fig. 2, is restricted in its distribution to the northern coast-line, and is taken in some abundance at Thursday Island and Cooktown. It not unfrequently attains to a length of fourteen or fifteen inches, and may be readily distinguished by its black dorsal cross-bars.

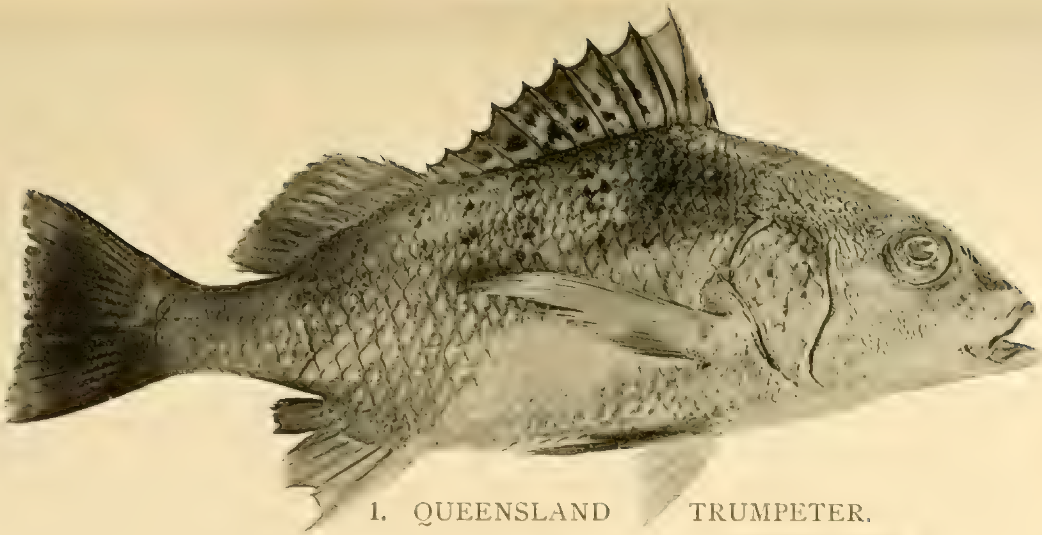
A second group of the Scombresocidæ, comprising fish of a much more considerable size than the Hemirhamphi, is represented by the genus Belone; it contains several Queensland species popularly called long-toms, gar-pikes, or alligator-gars. These fish, while somewhat resembling ordinary garfish in shape, grow to a length of from two to over three feet, and have both jaws prolonged in a beak-like manner, and armed with formidable teeth. The English representative of this genus, *Belone vulgaris*, Flem., is remarkable for the circumstance that its backbone, on being cooked, turns to a brilliant green hue, wherefore the fish is named the green-bone. A like peculiarity is reported to be associated with certain of the Australian varieties. No less than eight species of Belone have been recorded from Queensland waters, *B. depressa*, Poey., being the commoner one in Moreton Bay, the remaining species being most abundantly represented in the inter-tropical zone. Included among these is a relatively short, thick, and weighty variety, *Belone Krefftii*, Gth., having much the proportions of an English pike, and which is taken in the lagoons of the Fitzroy River, near Rockhampton. It grows to a length of two feet and upwards, with a weight of seven or eight pounds, and is locally known as the Fitzroy gar-pike. It is an excellent table-fish. The flying fishes, genus Exocætus, while not attainable in quantities sufficient for commercial purposes, are delicate eating, and belong to the same family group as the garfishes and gar-pikes. Two varieties, *Exocœtus volans*, L., and *E. nigripinnis*, C. & Val., are reported from Queensland waters, the latter as far south as Moreton Bay.

The small family of the Osteoglossidæ has included, up to within a recent date, but a single Australian species, *Osteoglossum Leichardti*, Gth., which is one of the most esteemed fresh-water food fishes of Queensland. It is the species known to the settlers and to the aborigines *par excellence* as the barramunda, and its flesh has been compared to that of the English salmon by those familiar with the two species. It grows to a length of two or three feet, and has an elongate compressed body, with a trenchant lower edge; the cleft of the mouth is

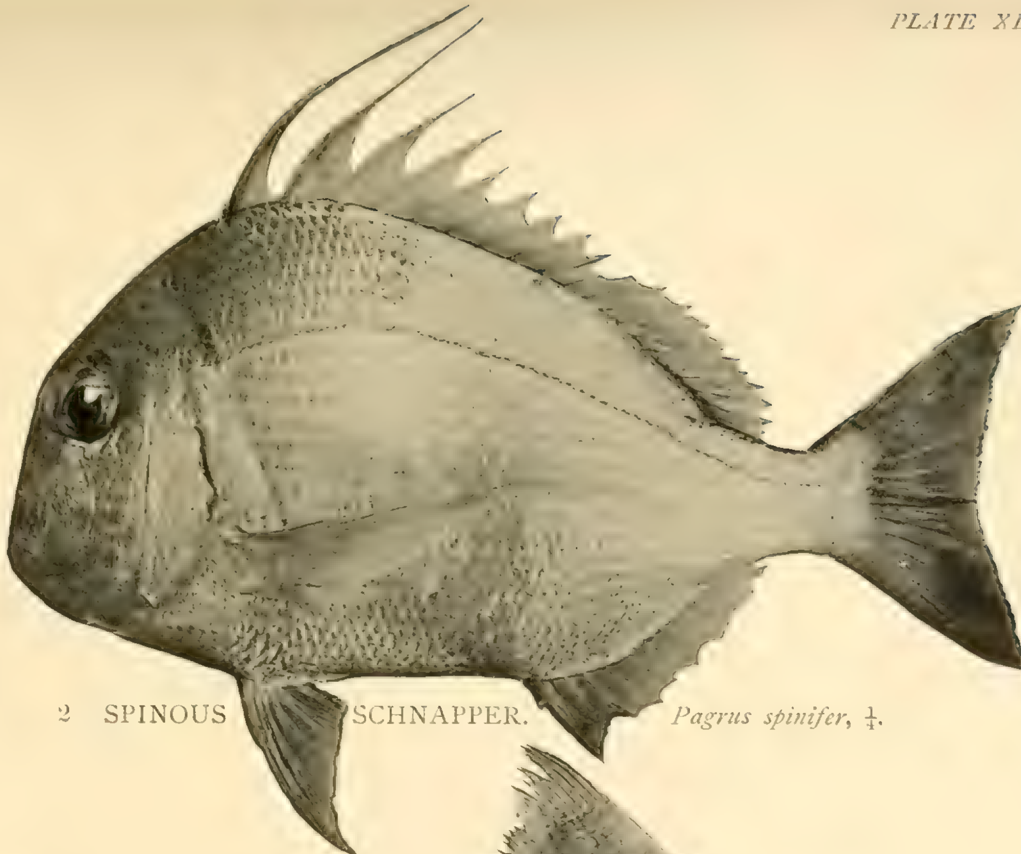
wide, obliquely set, and armed with a closely set row of sharp conical teeth; two short barbels depend from the prominent lower jaw. It occurs in the Fitzroy, Dawson, and other tributary inter-tropical Queensland rivers debouching on the Barrier coast-line, and is a species whose natural history and life habits might be advantageously studied with a view to its artificial propagation. It is a noteworthy circumstance that the only other two known species of the genus Osteoglossum—viz., *O. bicirrhosum*, Vand., and *O. formosum*, Mull., are inhabitants respectively of Brazil and Guiana, and Borneo and Sumatra. An allied form, *Arapaima gigas*, Cuv., also inhabiting the larger rivers of Brazil, is further remarkable as representing the largest Teleostean or bone-skeletoned fish yet discovered. This Arapaima has been known to exceed fifteen feet in length, associated with a weight of over 400 lb. It is highly esteemed as an article of food, and is salted and exported in large quantities from the inland fisheries, to the South American seaports. Another allied type, *Heterotis niloticus*, Ehr., is an inhabitant of the Upper Nile and various West African rivers.

The existence of a second species of Osteoglossum in Queensland waters has been recently established by the author. This variety is confined to the rivers of Cape York Peninsula, including the Batavia, Norman, and Gregory rivers, that debouch upon the Gulf of Carpentaria. A technical account of this new form, upon which, in honour of its discoverer, Mr. Frank Jardine, of Somerset, the title of *Osteoglossum Jardinei* has been conferred, was communicated by the author in 1892 to the December meeting of the Queensland Royal Society. Among the more salient features that serve to distinguish it from the single previous Australian species, are the more oblique cleft of the mouth, the considerably larger number of rays in both the dorsal and anal fins, the absence of a conspicuous spine in front of the last-named, and the distinct character of the colour-markings. In *Osteoglossum Leichardti* the majority of the scales are ornamented with one or, at most, two red spots. In *O. Jardinei* these spots are more usually represented by continuous crescent-shaped bands, which, above the lateral line, are, for the most part, divided up into three or four relatively small spots. A process-block illustration of this new species, reproduced from a photograph, is given on page 67.

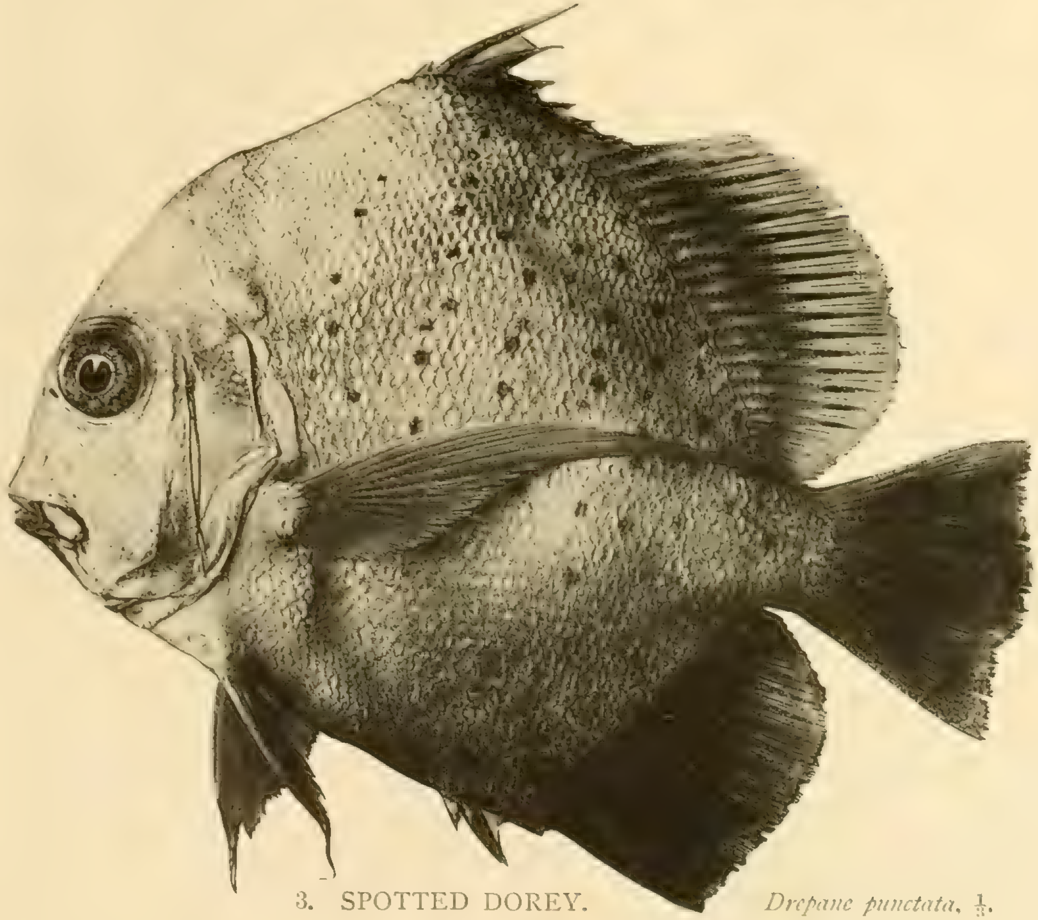
The herring tribe, Clupeidæ, occupies a position in the northern hemisphere with relation to economic utility that is surpassed by no other group of fishes. Though numerous species likewise abound in Australian waters, up to the present time their occurrence has been turned to little or no practical account. By way of example, it may be mentioned that an anchovy—one of the smaller representatives of the herring family—occurring in shoals on the Victorian and Tasmanian coasts, that is indistinguishable from its European congener, has hitherto been entirely neglected. There is also a pilchard, *Clupea sagax*, Jen., possessing all the essential qualities for making a first-class sardine, which European product, in its familiar tinned condition, is simply the young of the Mediterranean and Atlantic species, *Clupea pilchardus*, Walb. Queensland is by no means deficient in members of this important family. There are two species of anchovies, one of which, *Engraulis*



1. QUEENSLAND TRUMPETER.
Pristipoma hasta, ¼.



2 SPINOUS SCHNAPPER. *Pagrus spinifer*, ¼.



3. SPOTTED DOREY. *Drepane punctata*, ⅓.

4. BLACK BAT-FISH. *Str[illegible]*, ¼.

W. Saville-Kent. Photo.

[illegible]

BARRIER REEF FISHES.

nasutus, Cast., attains the (for an anchovy) considerable length of six or seven inches, and has a much deeper body than the European type. It appears in shoals, at certain seasons and usually after the rains, in Moreton Bay, its distribution extending thence to the northern seaboard, throughout the Malay Archipelago and India. In the last-named regions it already forms an important and valuable commercial product. As reported by Dr. Cantor in his "Catalogue of Malayan Fishes."—In Java, Sumatra, and the Straits of Malacca, large quantities of this anchovy are preserved for both home consumption and exportation to India, or China, in the form of a condiment known as "red fish," or, in the Malayan language, "Ikan Mérah." The Malay process of preparation is exceeding simple, being as follows:—After removal of their heads, the fishes are cleaned, salted (in the proportion of one of salt to eight parts of fish) and placed in flat glazed earthen vessels. In these they are submitted to pressure for three days, by means of stones, placed on thin boards or dried plantain leaves. The fish are next freed from salt and saturated with vinegar of cocoa palm toddy; there are then added powdered ginger and black pepper, the latter mostly entire, and some brandy and powdered "red rice" (*Oryza sativa*, var. *glutinosa*) steeped in an infusion of cochineal. After having been kept for three days, a little more vinegar is added, before placing the fish in well-closed jars or bottles. They should be kept four or five months without being used. The expense of preparing a quart bottle of this condiment is about 30 cents, the selling price one Spanish dollar. There is no reason why the shoals of this same anchovy, that periodically abound in Queensland waters, should not be turned to a similar practical and profitable account.

Of the herrings proper, genus Clupea, no less than eight Queensland species have been recorded. Some of these, at certain times of the year, are exceedingly plentiful, but none of them have up to the present time been utilised in this colony for commercial purposes. The majority of these herrings have an inter-tropical distribution, many of them, as in the case of the anchovy already referred to, being highly esteemed for food throughout the Malay Archipelago. Notably among these may be mentioned *Clupea sundaica*, Blk., which occurs plentifully in Torres Strait, and which travels, in its migrations, as far south as New South Wales. The late Sir William MacLeay, F.L.S., of Sydney, said that he looked upon it as far superior to the common herring of Scotland, as an article of food, and for the excellence and delicacy of its flavour. In common with an allied species, *Clupea sagax*, Jen., the maray or pilchard of the Sydney market, *C. sundaica*, arrives in winter off Port Jackson in enormous shoals, sometimes several miles in extent, then travelling north. This last-named type, *C. sagax*, does not appear to have been yet recorded from Queensland waters, though it is anticipated that it follows a course parallel with and outside the Great Barrier Reef. *Clupea sagax* is, at the same time, a more strictly temperate form; its migrations extending as far south as Victoria, Tasmania, and New Zealand. In the last-named colony the species is extensively cured and sold, under the title of the Picton bloater. Although not hitherto reported from the region of the equator, it makes its appearance again off

the coasts of Japan and California. *Clupea hypselosoma*, Blk., is another Queensland herring that collects in enormous shoals, sometimes joining those of *C. sundaica*, and which is equally esteemed for food. It may be distinguished from the species last-named by its deeper body. In order to initiate a successful fishery for these several migratory species of herrings which assemble in such vast shoals, drift net fishing, as practised in European and American waters, must be resorted to.

Some of the most remarkable representatives of the herring family inhabiting Queensland waters remain yet to be noticed. These include very giants of their tribe, the one form, *Chanos salmoneus*, Bl., known locally as the bony salmon, or milk-fish, attains, as recorded by Dr. Günther, to a length of four feet. It is of such excellent eating that in many parts of India, to which its distribution extends, it is domesticated and kept in large tanks, for sale to the wealthier inhabitants. It is a species that readily enters fresh water, and abounds in many of the rivers and estuaries on the Queensland coast-line, from the river Brisbane northwards. An illustration of this fine species is given in Plate XLVI., Fig. 6. A second giant herring, which attains to even larger dimensions than the foregoing species, is the so-called ox-eye, *Megalops cyprinoides*, Brouss., which may sometimes exceed five feet in length. The young of this fish freely enter fresh water, and it is by no means uncommon at Rockhampton, and in the estuaries of the various Queensland rivers northward from that point. It is highly esteemed for food, and in the Malay Archipelago, where it likewise abounds, it is cultivated in tanks after the same manner as *Chanos salmoneus*. This species is also illustrated in Plate XLV., Fig. 6. *Elops saurus*, L., is a third Queensland representative of the giant herrings, attaining to a length of over three feet, but it is not held in the same high estimation for the table. The same remarks apply also to *Albula conorhynchus*, Bl., a species equalling *Elops saurus* in size, which is often plentiful on the northern coast. Among other species belonging to the same family of the Clupeidæ have to be included the several varieties of so-called bony-bream, genus Chatoëssus, chiefly inhabiting fresh water, and one of which, *C. erebi*, Rich., is plentiful in the Brisbane and other Queensland rivers. While esteemed by some as an article of food, the abnormally bony nature of these fishes, whence their name, precludes their very extensive utilisation. *Brisbania Staigeri*, Cast, is another fresh-water member of the herring family, that is found in the upper reaches of the Brisbane River. There yet remains to be mentioned, in association with the herring tribe, a form of sprat, *Spratelloides delicatulus*, Beun., closely allied to a Malayan type, *S. gracils*, Sch., which, in addition to the anchovy, is extensively used in Celebes for the manufacture of the so-called "red fish." It is reported as abounding in many of the inter-tropical districts of the Queensland coast-line, and might doubtless be turned to commercial account.

A somewhat remarkable fish caught throughout the Queensland coast-line, but which is more particularly plentiful in the neighbourhood of Torres Strait, is the Dorab, or Silver-bar fish, *Chirocentrus dorab*, Forsk., belonging to the separate family of the Chirocentridæ. In aspect it

resembles an attenuated herring, but it is furnished with sharp prehensile teeth. As its name implies, it glitters like a bar of silver when taken from the water; it presents every appearance of being a first-class table fish, but, while of good flavour, it is unfortunately so full of small bones as to be almost useless. In common with the bony-bream, Chatoëssus, previously referred to, it could probably be turned to good account if cut into suitable lengths and preserved in tins, after the manner of sardines, under such conditions that the bones would be dissolved. The fish attains to a length of three feet, and occurs abundantly in tropical waters, from the African coast-line to the China seas. In the estuary of the Norman River the dorab is highly prized as a bait for the capture of the giant perch, *Lates calcarifer.*

The eel family, Murænidæ, is represented in Queensland by the cosmopolitan fresh-water species *Anguilla australis*, Rich., which is more or less esteemed for food, and by some three or four marine members of the same genus. There are also two conger eels, *Conger marginatus*, Val. a northern form, and *C. labiatus*, Cast., which is identical with the common conger of the Sydney market. The Murænæ, eel-like fish of a compressed shape, with the gape of the mouth extending a long way behind the eyes, are represented in Queensland waters by about twelve species, the majority of which belong to the tropical zone and frequent the coral-reefs. Some of these Murænæ, or Reef-eels, as they are popularly called, attain to a length of six or eight feet; and, being of aggressive habits and armed with formidable teeth, they command wholesome respect from the fishermen. In the days of ancient Rome it was not an uncommon practice to throw prisoners and malefactors into ponds to be devoured by Murænæ, which were kept expressly for this purpose. Voyagers to and from Australia, *viâ* Naples, have unexampled opportunities of studying the habits of these fish in the tanks of Dr. Dohrn's Zoological Station Aquarium, where a number are on view, domiciled, in many instances, in ancient Roman amphoræ. A species of Reef-eel, *Muræna tessellata*, Rich., that is tolerably abundant throughout the Great Barrier coral-reefs, is very distinctly marked, its entire body, including the head and fins, being dappled with rounded or more or less polygonal black spots on a white or cream-coloured ground; these spots are so closely approximated, that the colours might be almost more correctly described as black with white reticulations. In a preserved skin of this species, in the author's possession, about four feet long, the black polygonal areas enclosed by the white reticulations are rarely over an inch in diameter, and are most usually much smaller. The pugnacity of this mottled Reef-eel is evinced by the smallest examples, a foot or so only in length, that are commonly found on turning over rocks and coral boulders on the reefs, for they strike viciously at, and speedily draw blood from, the hand that attempts to capture them.

An allied and very ferocious species of Reef-eel, that attains to a length of as much as twenty feet, and of which the pearl-shell and Bêch-de-mer fishers are more in dread than of sharks, has been reported to the author, as frequenting the reefs in the vicinity of the

South Sea Islands, by a Barrier fisherman formerly engaged in the South Sea trade. Also, from the same locality, a small eel having very pronounced electrical properties. Neither of these species appear to be known to science, nor, indeed, does any marine species of Electric Eel; the only familiar type being the Gymnotus, that inhabits the fresh waters of South America. Rumours of a Barrier Reef electric species have likewise reached the author, but further evidence is desired for an authentic establishment of its existence.

Muræenesox, including *M. cinereus*, Bl., the pike-eel, Ophichthys, and Gymnomuræna are additional representative genera of the eel family, occurring in the Queenland seas, whose members may be associated with those fitted to yield a valuable and nutritious food supply. The first-named species, *Murænesox cinereus*, is photographically illustrated in Plate XLVII., Fig. 5. The abnormally "open" countenance of the fish is characteristically delineated in this portrait. The eye, as may be observed, is situated close to the end of the snout, while the mouth cleft is continued backwards through almost the entire length of the head.

The family of the Sirenidæ includes but a single known Australian species, the celebrated *Ceratodus Forsteri* Krefft., which is restricted in its distribution to the Burnett, Dawson, and Mary Rivers in Queensland. In association with two other types, *Lepidosiren paradoxus*, Fitz., of South America, and the African mud-fish, *Protopterus annectens*, Owen, it has been placed by biologists in a distinct sub-order of the fish class known as the Dipnoi. This group is specially remarkable for the fact that its members possess well-developed respiratory lungs in addition to ordinary gills, for which reason they may be appropriately named "lung-fishes." This and other important structural details have necessitated their relegation to a position at least physiologically midway between the class of ordinary fishes, and that of the amphibia, which includes the frogs and newts. The possession of supplementary lungs in this group, is no doubt a provision to enable the fish to live independently of the precarious or vitiated water supply of the districts they inhabit. In the case of the African species, the fish, on the approach of the dry season, construct for themselves shells, or cocoons, of mud, in which they hibernate or estivate until the return of the rains. In this condition they are dug up for food, after the manner of potatoes or yams. The Ceratodus, locally known to the settlers as the Burnett-Mary River salmon, and to the aborigines as a form of barramunda—which name should be restricted to Osteoglossum—attains to a length of six feet with a weight of from 20 to 30 or more lb. Its flesh, fortunately for the prospects of the conservation of the species, is not generally esteemed for food, being of a dark red hue, and somewhat coarse and oily. Individual opinions as to its merits on this point are, however, much divided. Although previously known to, and utilised for food by, the settlers and aborigines, the discovery of this remarkable fish to science dates no farther back than the year 1870. The interest attached to this genus, from a scientific standpoint, is heightened by the fact that fossil teeth belonging

to several allied species had been previously found in the triassic and jurassic strata of Europe, India, and America; and an allied genus, Gosfordia, has been, within the last three years, recorded from the Upper Triassic beds of New South Wales. Full details concerning the life-history and development of Ceratodus are still much needed. As so far observed, it appears to be essentially herbivorous. An illustration of this very remarkable fish is given on page 67, in association with *Osteoglossum Jardinei*, as a tail-piece to Chapter I.

Although not popularly classified among the ordinary food-fishes, it is worthy of mention that many of the species of leather jackets, genus Monacanthus, which abound in the Queensland and other Australian seas, are in many instances most excellent eating, their flesh when cooked—the skin being previously removed—having been compared to that of the sole and flounder. A somewhat remarkable species of this genus Monacanthus, in which a skinny, pouch-like, protuberance is developed from the ventral region, combined with an abnormal growth of the uppermost ray of the caudal fin, is illustrated by Plate XLVIII., Fig. 1. The specimen delineated was taken in Moreton Bay, but occurs farther north.

The shark tribe, included within the Order of the Chondropterygii, all the members of which possess cartilaginous skeletons (in distinction from the true bone or lime-impregnated ones of the ordinary fishes or Teleostei), does not contribute extensively to the stalls of the fish market. Various species of skate, however, which are merely flattened-out sharks, are highly esteemed in Europe for their esculent properties; and there are many allied forms in Australian waters that are equally eligible for the table, though hitherto but little utilised. Among the Queensland species, attention may be more particularly directed to the shovel-nosed skate, *Rhinobatus granulatus*, Cuv., illustrated by Plate XLVIII., Fig. 4, which, on the authority of gastronomic experts, is considered equal, if not superior, to any of the most favoured British species. The fish, being plentiful from Torres Strait to Moreton Bay, and growing to a length of six or seven feet, with an associated weight of upwards of 100 lb., represents an increment of wholesome food that would not be suffered to run to waste within reach of any large European centre of population. Another allied form, *Rhynchobatus ancylostomus*, which is less commonly seen in Queensland waters, grows to a corresponding size and weight. In Indian waters it is known as the mud-skate, and according to Dr. Day ("Fishes of India"), it is much esteemed for food, flesh being considered highly nutritious, in either a fresh or salted condition.

The sub-class of the Cyclostomata, including the suctorial-mouthed lampreys and allied types, is represented by no known form in Queensland waters; though several species, including the singular-pouched lamprey, Geotria, are indigenous to Tasmania, Victoria, and other of the southern Australian colonies.

A brief reference may be made, in conclusion, to a few supplemental forms not falling within the category of food fishes, delineated in the accompanying photographic and coloured illustrations, which are incorporated on account of their singularity of contour, remarkable colours,

or other special features. The sucking-fish, *Echeneis naucrates*, delineated by Figs. 1A and B of Plate XLV., represents one of the aberrant members of the mackerel tribe, or Scombridæ, remarkable for the adhesive disk on the top of its head. This structure is a modified derivative of the anterior dorsal fin, consisting of a double series of cutaneous lamellæ which, on being erected at will, produce, in conjunction with the external membranous border, a perfect vacuum. With this adhesive organ the sucking-fishes are in the habit of attaching themselves to sharks, turtles, and sailing vessels, utilising the selected object, in either instance, merely as a means of locomotion. The species here figured grows to a length of three feet, and, as related in the succeeding chapter, is employed by the natives of Torres Strait for the capture of turtle.

Two large species of fish belonging to the shark tribe, possessing no marketable value, not hitherto referred to, are included in Plate XLVIII. One of these, Figs. 2 and 3, known as the horned- or ox-ray, *Dicerobatis eregoodoo*, Cuv., is remarkable for the enormous size to which it may attain. In Queensland waters, in the neighbourhood of the Palm Islands, a specimen has been captured measuring twelve feet across the expanded fins, and others of nearly equal dimensions have been reported to the author from various localities in the Barrier district. On the Indian coast, however, specimens have been captured measuring over eighteen feet in width. This Oriental ray appears to be perfectly harmless, but there are two allied species—*Dicerobatis giornæ*, of the Mediterranean, and *Ceratoptera vampyrus*, of the Carribbean seas—locally known in the former instance as the Vacca or Sea-cow, and in the latter as the Devil-fish—that possess the evil reputation of attacking divers when engaged in collecting sponges and pearl-shell, intercepting their attempts to regain the surface.

The Queensland species, from its habit of basking on the surface of the water, is popularly known as the sun-fish. It has been reported to the author by Captain Thomson, the very observant commander of the A.U.S.N. Co.'s steamer *Quirang*, that this fish, impelled apparently with the desire of evading some enemy, will spring out of the water to a height of at least twenty feet. The ox-ray, as will be recognised by its form, is very nearly allied to the sting-rays of the genus Trygon and Myliobatis, but differs from them in being devoid of a caudal spine, and in the peculiar horn-like prolongation of the anterior edge of the pectoral fins. The teeth in the members of this genus are relatively minute and weak, and not modified, as in the case of the sting-rays, Trygon, for crushing hard shell-fish and crustacea. This circumstance and its floating habits, appear to indicate that it is a surface feeder, feeding upon the vast shoals of larvæ and other organisms that swarm on the upper stratum of the tropical seas in calm weather. It has furthermore been observed of examples floating on the surface of the water, that the horn-like appendages, which are exceedingly flexible in life, are frequently inflexed towards the mouth, as though sweeping in the water with its suspended contents. The extreme width of the mouth, discernible in the accompanying illustration (Fig. 2), which opens disclosing a cavity like a carpet-bag, and the wonderfully complex modification of the gill arches, which un-

doubtedly fulfil, as in the case of the baleen-plates of the whale, the function of a most efficient sieve, lend substantial support to the opinion here advanced (it is believed for the first time) that these giant rays feed absolutely and entirely on surface organisms.

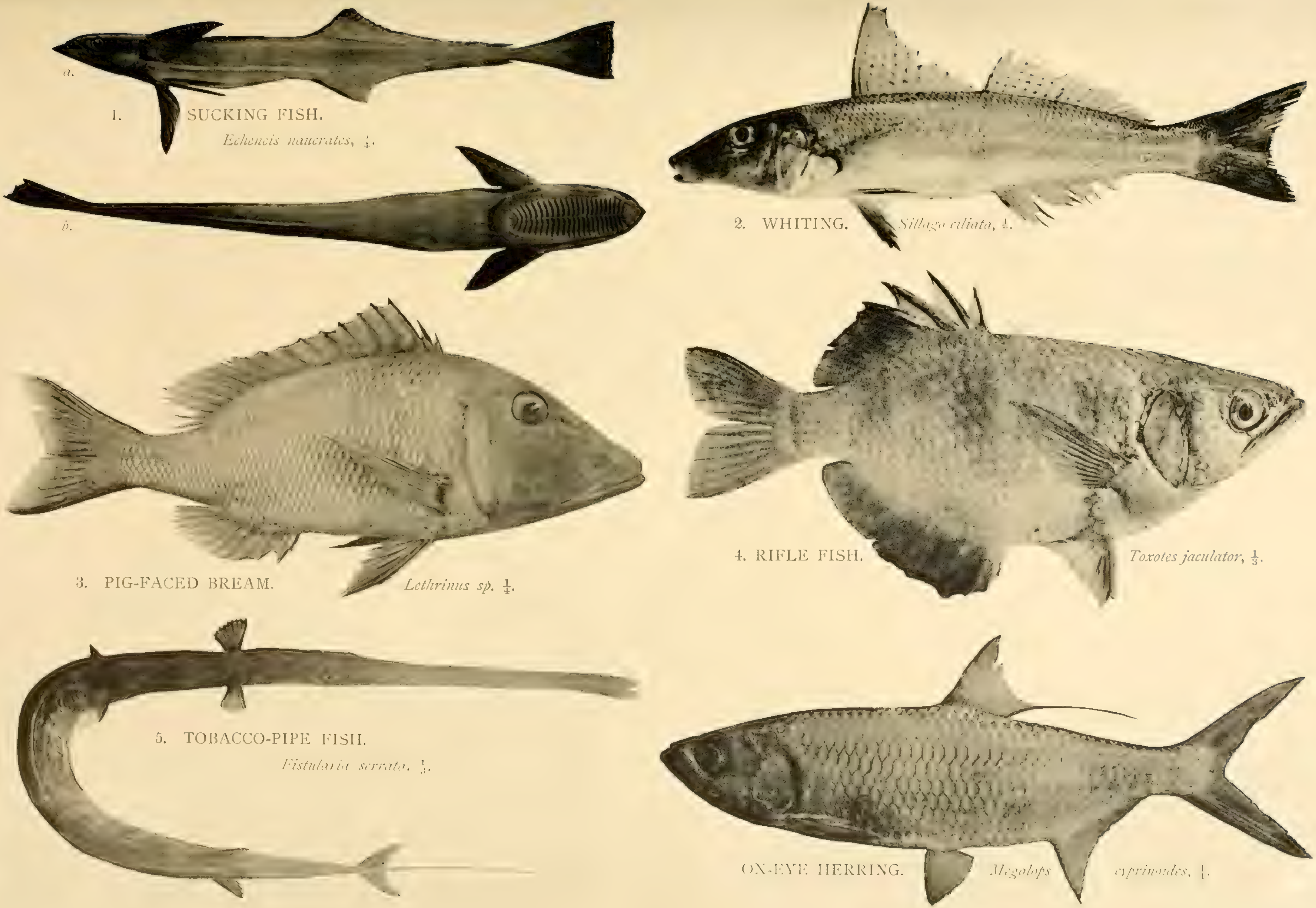
The one photographic fish portrait that yet remains unnoticed, is that of the carpet shark, Crossorhinus, depicted in Plate XLVIII., Fig. 5. The general aspect of this form is much like that of the angel or monk-fish, *Rhina squatina*, indigenous to the British seas, but possessing a cosmopolitan range of distribution that extends to California, Japan, and Australia. The type here figured differs essentially, however, from the monk-fish in the fact that the gill-apertures, distinctly visible in the picture, open on the upper in place of the lower surface, a circumstance that indicates its nearer affinity with the ordinary sharks, rather than with the rays and skates, in which the gill-apertures are always situated ventrally. Several species of carpet sharks have been described ; and while all inhabit the Australian seas, one form extends in its distribution to Japan. Their specific distinctions are associated, for the most part, with the proportionate development of the skinny flaps or tentacle-like appendages around the sides of the head. The type here figured was obtained at Thursday Island in Torres Strait. It was at first anticipated to be identical with *Crossorhinus tentaculatus*, Peters, indigenous to the same vicinity, and it has consequently been associated with that title in the illustration. A subsequent investigation of the diagnostic features of the several known species has resulted, however, in its more correct relegation to the *Crossorhinus dasypogon* of Bleeker. The commonest Australian species, *Crossorhinus barbatus*, Lacep., which occurs as far south as Victoria and Tasmania, is popularly known by the New South Wales native name of the "Wobbegong." All the known species grow to a length of six or seven feet ; like the monk-fish, they repose during the daytime on the sea bottom, and move about stealthily at night in search of food.

A few of the smaller fish delineated in Chromo plate XVI. invite brief notice. Of these, the specimens depicted in Figs. 3 and 6 agree with one, in the matter of the abnormal elongation of the snout, at the extremity of which, in either case, the tiny mouth is situated. Both species are referable to the same family group of the Centriscinæ, and possess features in common, in addition to that of the snout elongation. Fig. 6, *Centriscus scolopax*, L., popularly known as the trumpet or bellows fish, is conspicuous for the remarkable proportionate development of the anterior dorsal spine, which is directed obliquely backwards. In the allied form, Fig. 3, *Amphisile scutata*, L., here distinguished as the needle-fish, the backwardly-set disposition of the dorsal spine is so abnormally exaggerated, that its axis is continuous with that of the body, while the true tail, or caudal fin, is so modified as to appear situated immediately behind the anal fin on the ventral surface. Another peculiarity of this species of Amphisile is that its body is so compressed laterally that, from a vertical point of view, it is no thicker than a sheet of blotting-paper, notwithstanding its investment in a cuirass of thin bony plates in lieu of scales. It

is suggested in Dr. Günther's "Catalogue of Fishes," Vol. III., p. 527, that it may be regarded as a Chelonian, or tortoise-like form, among fishes.

Figs. 4 and 9 of Chromo plate XVI. represent two little gems of the parrot-fish tribe, referable to the genus Labroides. Both of them occur in some abundance in the coral pools of the Lady Elliot Island reef, and have also been observed by the author farther north. Having no hand-nets at the time, attempts to capture them were unsuccessful, and the coloured drawings of them here reproduced were accordingly made from the fish as observed swimming in the pools. They may, consequently, while correct as to tint, be less strictly accurate in delineation than the figures drawn from handled specimens. So far as the identification of these two fish with previously described species is concerned, the one, Fig. 4, bears some slight resemblance to the black and white banded *Labroides dimidiatus,* C. & V.; but concerning the second form, no near affinity has been discovered. In both instances, it has been considered desirable to associate the fish, at any rate provisionally, with a new specific title; that proposed for the black form, with turquoise stripes, being *Labroides bicincta,* and that for the blue-bodied and yellow-finned variety, *Labroides auropinna.* The very small black and white striped fish represented by Fig. 7 of the same Chromo plate is apparently a young example of *Amphiprion Clarkii,* Bann., and is possibly associated commensally, in its adult stage, with some large sea-anemone, as is the case with *Amphiprion percula,* Lacep., and *A. bicinctus,* Rupp., referred to in a previous chapter. The grey fish with a yellow tail, delineated in Fig. 11 of the same plate, is an undetermined species of Glyphidodon, belonging to the same family group provisionally named *Glyphidodon luteo-caudata.*

One of the most beautifully tinted fish in this series is that represented by Fig. 8, associated with the title of *Polyacanthus Queenslandiæ.* Some diffidence has been experienced in assigning this fish to the genus Polyacanthus, it being, as hitherto known, an essentially fresh-water genus inhabiting the rivers and estuaries of Hindoostan, China, and the islands of the Malay Archipelago. The genus belongs further to a family, the Labyrinthici, furnished with a special epi-branchial organ in which they retain water, and by which they are enabled to keep their gills moist and to sustain life for considerable intervals when removed from their native element. The well-known climbing perch, *Anabas scandens,* C. & V., and the excellent-eating Gourami, *Osphromenus olfax,* Lacp., belong to the same peculiarly modified family group. The single specimen obtained, from which this drawing was made, was caught by one of the seamen of H.M.S. *Rambler,* on the rocky foreshore of Adolphus Island, off Cape York, at the entrance to Torres Strait; but it was unfortunately subsequently lost, through the overcrowding of specimens in the receptacle used for its conservation. The general shape of the fish, and the peculiar elongated terminal contours of the dorsal, anal, caudal, and pectoral fins, correspond essentially with those of *Polyacanthus cupanus,* C. & V., figured in Plate LXXVIII. of Dr. F. Day's "Fishes of India," with a recorded habitat at the Malabar and Coromandel coasts, and as also found there in ditches and shallow waters within, or not far removed from tidal influence. It is furthermore remarked by Dr. Day that, while the more



1. SUCKING FISH. *Echeneis naucrates*, $\frac{1}{4}$. a. b.

2. WHITING. *Sillago ciliata*, $\frac{1}{4}$.

3. PIG-FACED BREAM. *Lethrinus sp.* $\frac{1}{4}$.

4. RIFLE FISH. *Toxotes jaculator*, $\frac{1}{3}$.

5. TOBACCO-PIPE FISH. *Fistularia serrata*. $\frac{1}{3}$.

OX-EYE HERRING. *Megalops cyprinoides*, $\frac{1}{4}$.

W. Saville-Kent, Photo.

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BARRIER REEF FISHES

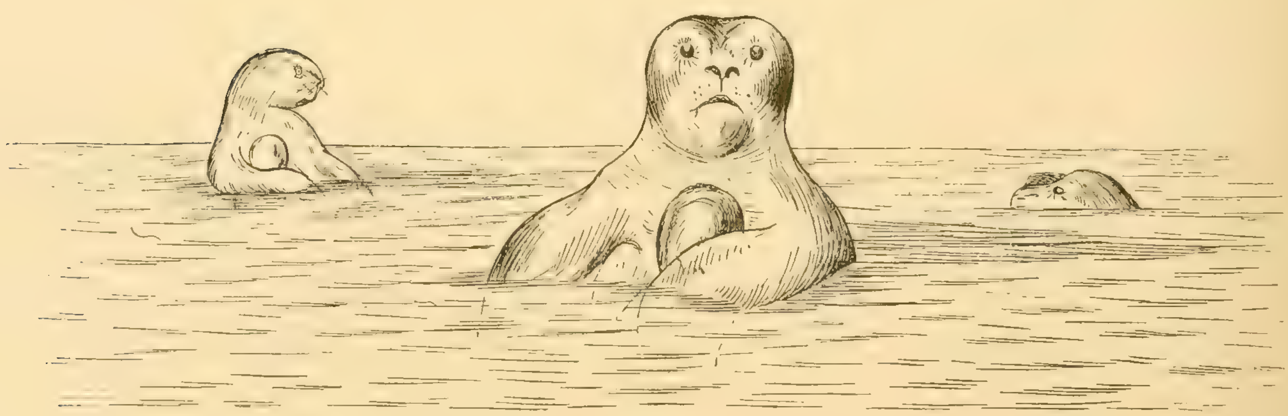
ordinary colour of the species is "rifle-green with the prolonged ventral ray scarlet," a rose-coloured variety with two horizontal black marks—here regarded as probably representing the male fish in his wedding vestments—is occasionally met with. A second rose-coloured species, *Polyacanthus Deissneri,* Bleek., having a larger number of black bands, is also recorded by Dr. Günther, "Catalogue of Fishes," Vol. III., p. 381, as inhabiting the rivers of Baturussak, in the island of Bawean. The present form being evidently a new type of a genus not hitherto associated with the Australian fish fauna, it is here distinguished by the title of *Polyacanthus Queenslandiæ.*

The horned-trunk fish, or cow-fish as it is sometimes called, *Ostracion cornutus,* L., represented by Chromo XVI., Fig. 10, is a tolerably familiar type, in its dried condition, in all museum collections. Coffer or Box fishes are other names by which the various species are known, all bearing reference to the indurated, box-like carapace, that represents the pliable, scale-covered integument of most ordinary fishes. The majority of the species are brilliantly coloured, the males usually eclipsing the females in this respect. In certain forms, including, more particularly, a southern, Victorian and Tamsanian, species, *Ostracion (Aracana) ornata,* the males and females differ so essentially in colour, that they are classified in standard works on ichthyology (including Dr. Günther's "Catalogue of Fishes," and MacLeay's "Australian Fishes") under the two respective titles of *Ostracion ornata* and *O. aurita.* The life tints of the male, in this instance, consist of a ground colour of rich grass- or emerald-green, with longitudinal stripes and spots of the most brilliant ultramarine blue, whilst that of the female is pale yellow or flesh-colour, with narrower, brown, undulating lines. Specimens of this type, obtained in Tasmania, and dissected by the author, demonstrated that the male and female reproductive elements were associated respectively with the blue and brown striped fishes, while a yet more positive proof of the resulting inference was afforded by the capture of a "hermaphrodite" specimen, in which the colour patterns of the hitherto supposed separate species were combined on opposite sides of the same individual.

The little green and scarlet speckled fish, represented by Chromo XVI. Fig. 12, belongs to the genus Gobius, a cosmopolitan one, abundantly represented the world over, including British waters. Its mimetic resemblance to the parrot-fishes, with which it consorts in the coral-pools of the Barrier reef, is very remarkable, and is, so to say, a correlation of the mimetic phenomenon that obtains among the avi-fauna on the adjacent mainland, where pigeons and finches, usually of more sombre tints, are found arrayed in the verdant green plumage associated *par excellence* with the parrots. The fish here figured bears a considerable resemblance to *Gobius ornatus,* Rupp., reported from Port Darwin. That species, however, while possessing a similar green body, is ornamented with brown spots and yellow dots, while all the fins except the ventrals are dotted with black; there would appear also to be a total absence of the stripes, on the cheeks and operculum and at the base of the pectoral fin, that characterise the Queensland type. The specimen figured in this volume having been received, in its living state, from the

Hon. John Douglas, the Government resident at Thursday Island, it is, as a new species, herewith associated with the distinctive title of *Gobius Douglasi.* Additional specimens of the same variety were subsequently obtained, at several more southern stations in the Barrier system.

The lowermost illustration, Fig. 15, of Chromo Plate XVI., represents a species of pipe-fish, *Gastrotokeus biaculeatus,* Bl., that is tolerably plentiful in Torres Strait and some distance further south. It belongs to the same family group, the Syngnathidæ, that includes the quaint sea-horse, Hippocampus, and yet more remarkable dragon-fish, Phyllopteryx. It differs from the ordinary pipe-fishes of the genera Syngnathus and Siphonostoma represented in European waters, while it agrees with the allied Nerophis, therein met with, in the fact that the male fish—which discharges the greater share of the customary maternal functions throughout the family—has not a special abdominal or caudal pouch, for the reception and nurture of the eggs and embryonic young, these being merely adherent to depressions in the under surface of the body wall. The specimen here delineated represents such a male fish, fully freighted with his embryonic brood. From the fancied likeness of the contour of the head of this species to that of an alligator, it is popularly named the Alligator Pipe-fish.



"MERMAIDS"—FEMALE DUGONGS NURSING THEIR YOUNG. (AFTER EMERSON TENNANT)

CHAPTER IX.

POTENTIALITIES.

MANY and various are the potentialities of the Great Barrier Reef of Australia. They are associated, practically, with every one of the several fishing industries described in the preceding chapters, and include numerous subjects hitherto untouched.

Beginning with the latent resources of Queensland's—or in its restricted sense, the Barrier's—marvellous fish-fauna, they present almost unlimited possibilities of profitable development. As shown in the preceding chapter, its waters abound with shoals of fish akin to the European herring, mackerel, anchovy, and pilchard, which up to the present date have been literally allowed to run to waste. And yet, with these indigenous supplies swarming at their doors, Queensland and all the neighbouring Australian colonies import vast stores of tinned, smoked, and salted fish, from the lordly salmon to the lowly sprat, from Europe and America. The sapid sardine—the "stand-by" and *sine quâ non* of every settler's station, prospecting camp, or yachting cruise—represents, in large measure, English sprats, caught and tinned at Deal, on the Kentish coast, sent over to France to be branded, and thence reimported and distributed the world over as primest French sardines. The sardine, as a specific form of fish, possesses no real existence. At its best, it is but the young of the European pilchard, *Clupea pilchardus*, the equal, and in some opinions the superior, of which exists in the vast shoals of *Clupea sagax* and *C. sundaica* in Queensland waters. The garfishes, Hemirhamphi, celebrated for the delicacy of their flavour, and represented, as already shown, by numerous species procurable in bulk, would undoubtedly, if tinned *à la sardine*, command a ready sale.

The so-called king-fish, or giant mackerel, *Cybium commersonii*, belonging to the mackerel tribe, and occurring in shoals in the northern districts of the Barrier, is as well-suited as the British mackerel or its near ally, the Mediterranean tunny, for smoking, salting, and other methods of conservation. The schnappers, sea-breams, and so-called rock-cods (Serrani) that abound in endless varieties throughout the Barrier district, are equally eligible for such a

purpose, and would surely be an improvement on the casks of salted ling, imported and consumed through the length and breadth of the colony. So little are the natural resources of the indigenous Queensland fish-fauna turned to account that, on a recent visit to Thursday Island, the author found that smoked fish, cured by an enterprising Manilla man, were being imported in quantities from New Guinea, for the use of the crews of the Torres Strait pearling fleets. Trevallies, Polynemi, Grey-Mullets, King-fish (Cybium), Drepane, and Chorinemus represented the leading forms, equally abundant in Queensland's home waters, which were thus being imported from the territory in process of redemption from barbarity.

The giant herrings, *Chanos salmoneus* and *Megalops cyprinoides*, are referred to in the preceding chapter as being so highly valued in India, that they are thought worthy of culture in tanks, for the food supply of the wealthier classes. The young of the last-named species, more particularly, abound in the fresh- and brackish-water lagoons in the vicinity of Townsville, and might easily be there made the object of practical experiment. Among other fish of superior esculent qualities, the tassel-fishes, Polynemi, are qualified to hold high rank; and one species in particular, *P. tetradactylus*, on account of its excellent flavour, has won for itself the local name of salmon. These Polynemi, moreover, as previously remarked, are highly valued in India, on account of the considerable and excellent quality of the isinglass they produce; and they are thus doubly worthy of attention. A fish, *Psettodes erumei*, allied to, and fitted to take the place of, the English brill or turbot, is, as shown on a previous page, a denizen of Queensland waters hitherto overlooked.

In the matter of fish more suitable for relishes than for substantial food, anchovies of various descriptions abound, including one species, *Engraulis nasutus*, that is much prized in the Malay Archipelago for the production of the famous condiment "Red-fish," or, in the Malay language, "Ikan Mérah." A fish closely allied to the famous "Bummaloe fish," or "Bombay duck," *Harpodon nehereus*, and eligible for similar preparation as a curry adjunct, is ready to hand in the smelt-like species, *Saurida argentea*, collected by the author at numerous stations on the north-east coast-line, and figured in Plate XLVI., Fig 3.

In yet another direction, there exists an almost unlimited field for the more profitable utilisation of the rich fish-fauna of Queensland. Attention is here directed to the circumstance that in the shark tribe, including the sharks, skates, and rays, so abundantly represented in Queensland waters, there exist the raw materials for several highly remunerative industries. Dried sharks' fins, throughout India, China, and the East, form a very important commercial staple, the value of this product exported during a single year, from Kurrachee alone, varying, according to published statistics, from between 15,000 to 18,000 rupees. The carcases of sharks, furthermore, form a splendid manure. The smaller varieties, chiefly Galeus, Mustelus, and Acanthias, are extensively used in this manner for the fruit orchards of Tasmania, and fetch from 30s. to 40s. per ton. A similar use might doubtless be profitably made of the

many Queensland species, in connection with the sugar-cane and other coastal agricultural crops. From the livers of all these fish there is, finally, expressible various specific qualities of oil, which command a high price in the market. It need scarcely be mentioned that, concurrently with the destruction and commercial utilisation of the rapacious members of the shark tribe, material protection would be given to all the other more important fisheries.

It is difficult, in face of the substantial evidence forthcoming, to comprehend how it is that the colony does not draw more extensively on her indigenous waters for food supply, or why, with so abundant and varied a fish-fauna, so much fish should be imported. The true solution of this problem is doubtless, to a very considerable extent, bound up with the labour question ; the wages earned by workers in every industrial sphere being, at present, so abnormally high, as to render it scarcely possible for them to compete with the cured or otherwise conserved fish-industries centred in cheap labour districts. That there is a growing tendency, however, for matters to rectify themselves in this respect is apparent in many directions ; one of the most suggestive signs of the times being the numbers of the unemployed that enrol themselves for Government labour, in increasing rather than in diminishing ratio, in almost every Australian city. So soon as the labour equilibrium shall be more nearly reached, abundant employment should be forthcoming, in association with the suggested fishing industries.

The fishing industries of Queensland, so far as they relate to the fresh fish supplies of the larger centres of population, are practically in their infancy. Even Brisbane, the capital, does not yet possess a localised fish-market, while the fish placed at the disposal of the Brisbane public are entirely limited to what are termed "long-shore"—varieties taken with the seine, and represented mainly, so far as bulk is concerned, by various species of grey mullets. Long-line fishing, and fishing with trawl, trammel, drift or set nets, are altogether unknown. Even ordinary hand-line fishing for the public supply is altogether neglected, schnapper and the many other fine sea-breams and perches, that abound just outside Moreton Bay, being left entirely to the attention of amateur fishing parties. The explanation of this anomaly is that, there being no central market where the fish can be sold by healthy competitive auction, all supplies are monopolised by a small ring of salesmen, who give one fixed price, averaging 12s. per bushel-basket, for every description of fish. There is, consequently, no inducement to the fishermen to go further a-field for the capture of the choice varieties of fish, or to resort to any other than the simplest and most expeditious methods of capture. So soon as the long-contemplated, well-appointed fish-market becomes a substantial reality, the present conditions of the public fish-supply will undoubtedly be vastly improved, and a far more lucrative remuneration will be thrown open to the working fisherman.

At several of the coastal townships of the northern district, such as Townsville, Cairns, and Cooktown, the Indo-Malay method of capturing fish in enclosed fish-weirs, or pounds, is success-

fully practised. It owes its origin, in most instances, to the initiative of Malay or Chinese fishermen. A very considerable number of varieties of fish are taken by this method, with not unfrequently, in the Townsville fishing-weirs, a stray crocodile. It is an interesting circumstance that the remains of very extensive stone-built fishing-weirs exist at Darnley Island, in Torres Strait, of the origin of which neither the present inhabitants nor those residing there at the date of Jukes' visit (1843) have possessed any knowledge.

Trawling is not a method of taking fish that is likely to prove remunerative in Queensland waters, and more especially among the intricate channels of the Barrier. In addition to the sea-bottom being too rough and uneven for the effective working of the trawl, there is an insufficiency of that particular class of bottom fish, such as soles, turbot, brill, plaice, skate, and gurnards, of marketable size, which constitute the main harvest of the trawl-fisher in European waters. Experiments with the trawl were conducted by the author in both Moreton and Cleveland Bays. The results obtained, however, while interesting from a scientific point of view, yielded little or no materials of commercial value. By such time as the Queensland fisheries are exploited to the extent of the development of an important export trade, it may be anticipated that the use of the trammel, drift, and other meshing-nets will be found most efficient for the capture of many important varieties.

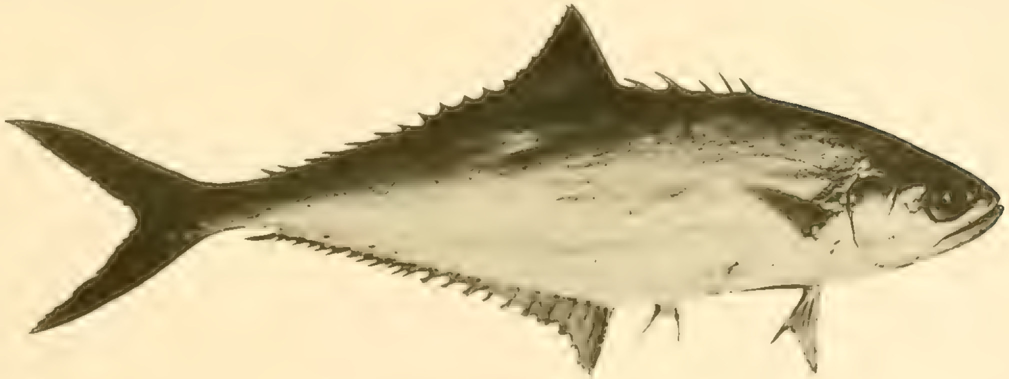
As a means of increasing the natural fish supply, and more especially with the view of providing high-class and attractive sport, the introduction and acclimatisation in Australian waters of British and other Salmonidæ has, in certain of the more southern colonies, been attended with a considerable amount of success. The question was submitted to the author, while Commissioner of Fisheries to Queensland, whether it would not be practical to similarly introduce representatives of the family into that colony. The matter was raised in association with a liberal offer made to the Government of a supply of ova of the Californian salmon, *Salmo quinat*, but which the author did not feel justified in recommending them to accept. Trout, *Salmo fario*, has been successfully acclimatised in the colonies of Tasmania, Victoria, and New South Wales; and *S. levenensis* in the Neilgherry Hills in India. The author is of the opinion that it might be possible also to introduce the former species into the upper waters of the Barron River and other streams at a high and relatively cool elevation, in Queensland. Money expended on the introduction of salmon of either the Atlantic, *Salmo salar*, or the Pacific, *S. quinat*, species would undoubtedly be simply wasted, as has unfortunately been the case with experiments conducted on a large scale, and extending over many years in the colony which offers, apparently, the most favourable conditions for salmon acclimatisation.

Since the year 1864, when the first consignment of British salmon ova arrived in Tasmania by the ship *Norfolk*, the most earnest and praiseworthy efforts have been made by enthusiastic anglers and others in that colony, constituting collectively a special salmon commission, to establish salmon in its waters. Thousands of pounds of the colony's money,

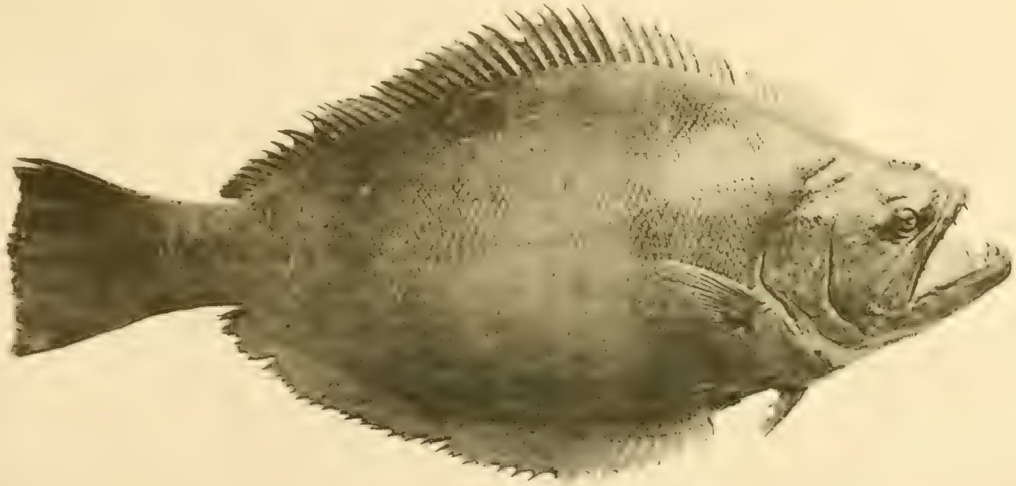
1. KING FISH. *Cybium commersoni*, $\frac{1}{5}$.

2. COOKTOWN SALMON. *Polynemus tetradactylus*, $\frac{1}{6}$.

3. SMELT. *Saurida argentea*, $\frac{1}{2}$.



4. QUEEN FISH. *Chorinemus lysan*, $\frac{1}{4}$.



5. QUEENSLAND HOLIBUT. *Psettodes erumei*, $\frac{1}{4}$.

6. GIANT HERRING. *Chanos salmoneus*. $\frac{1}{5}$.

W. Saville-Kent, Photo.

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BARRIER REEF FISHES.

and liberal sums contributed by private individuals, have been expended on the effort to acclimatise the fish; but still, Tasmania has no salmon. Trout, of both the English and American species, *Salmo fario* and *S. fontinalis*, and also the salmon-trout, *Salmo trutta*, with many interesting racial varieties, Tasmania possesses in abundance; and all of these afford most excellent sport to residents of, and visitors to, the colony. *Salmo fario*, in particular, as established in the inland lakes and larger rivers, has developed in the direction of the form familiarly known in England as the Great Lake Trout, formerly classified as a distinct species, under the title of *Salmo ferox*, and which may scale up to a weight of twenty or even thirty pounds. The true salmon, however, still remains, as heretofore, represented only by its commissioners.

This disappointing condition of affairs, after the expenditure of thousands of pounds on the importation and successful hatching out of millions of ova and fry, is scarcely a satisfaction, and the anomaly for some time seemed to defy discovery. With some of the latest attempts to bring about a more successful issue of the experiment, the author was intimately associated. In the year 1884, a further specially-selected consignment of 130,000 salmon ova was imported to Tasmania per ss. *Yeoman*, and for their reception the hatching-house on the River Plenty was enlarged and entirely remodelled, on a more modern American system, to the author's plans. Over 35,000 healthy fry were raised from this consignment, and, in accordance with the author's recommendations, they were distributed among many of the northern as well as the southern rivers. In the hatchery ponds and in the rivers, the fry throve as heretofore, attained to the parr, and finally to the migratory, smolt condition. Following their natural instincts, they then descended to the sea, but, in place of returning to the rivers the following or succeeding years as grilse or fully-matured salmon, they were entirely lost sight of. Many and various were the interpretations suggested concerning their mysterious disappearance, the most generally accepted one being that, on their arrival in the sea, they were devoured by sharks. A young salmon, however, is probably as well, if not better, able to get out of the way of these sea monsters than the hosts of other fish that abound in the Tasmanian waters; while the circumstance that the salmon-trout, which is also a migratory fish, goes to sea and returns to the rivers without let or hindrance, is a refutation of this hypothesis.

The only logical interpretation of the unwelcome fact is, in the author's opinion, associated with the question of temperature. The published isothermal charts, and a temperature record maintained by the author, in association with the marine fish hatchery and ponds established near Hobart, demonstrated that the mean temperature was ten degrees Fahrenheit higher than that of the waters of the British seas; it corresponded practically with that of the coasts of Spain and the south of France, which lie outside the limits of distribution of the Atlantic salmon. It was consequently anticipated that the salmon, on their arrival in the sea, found its temperature too high, and wandered off, and were lost, probably, in the antarctic regions, in search of cooler water. The precisely similar negative results that have attended the experimental acclima-

tisation of salmon in the rivers of France that flow into the Mediterranean, strongly support this conjecture.

Tasmania has naturally been most reluctant to accept so uncompromising a verdict respecting her prospects of becoming a salmon-producing country, and it has been a sorry and thankless office on the author's part to be forced time and again to refuse a certificate as a *bonâ fide Salmo salar*, to various and sundry salmon-trout and brobdingnagian common trout, which have been submitted for his judgment. Other high priests from the ranks of fishery experts have even been brought out from the old country to prophesy better things; but the comfort so dearly brought was on a par with that conceded to the Moabites by the Prophet Balaam—unless the declaration that certain of the fish would be sold *as* salmon in the Irish market was a sufficient satisfaction. An elegant silvery fish, termed the bass, *Labrax lupus*, it may be here added, is also sold, with its spinous fins removed, *as* salmon, in many market towns of the Welsh Principality.

In face of the facts recorded in the preceding paragraphs, the attempted acclimitisation of salmon either in Queensland or any other Australian colony, is not recommended. The introduction, in fact, of any exotic species, where a country already possesses good indigenous fish is scarcely to be encouraged. The indiscriminate distribution of brown trout in every accessible river in Tasmania, has already exterminated from many of them a most excellent native grayling, *Prototroctes marœna*, which, both for the table and for the capital sport it yields to the fly-fisher, is held in high repute. The species in a few more years, if not aided—as it has been practically demonstrated by the author that it can be—by artificial propagation, will probably become extinct in that colony. Queensland already possesses many excellent fish varieties well worthy of attention, when times are riper, in the direction of artificial culture and propagation. The genuine barramunda, *Osteoglossum Leichardti*, if all the good things said of it be true, is a first-class table fish, which rises well to the fly, and might be advantageously introduced into the rivers south of the Fitzroy and its tributaries. The giant herrings, *Chanos salmoneus* and *Megalops cyprinoides*, are, like the English salmon, anadromous species, migrating between the rivers and the sea; and for their excellent esculent properties, are, as already shown, extensively cultivated in India. The tassel-fishes, Polynemi, include also a number of species of similar habits, large size, and excellent gastronomic and sporting qualities. With all these, and many other valuable indigenous varieties to draw upon, Queensland has less cause, probably, than any other Australian colony to look abroad for species to acclimatise.

The potentialities of the oyster fisheries of Queensland and the Barrier district are very extensive. As suggested in a preceding chapter, there are vast quantities of the essentially marine species, *Ostrea mordax* and *Ostrea nigro-marginata*, which grow in the greatest profusion on the reefs and islets of the Barrier system, that are especially eligible for tinning or other methods of conservation. Respecting the ordinary commercial

species, *Ostrea glomerata*, capabilities exist for increasing the present output, and of extending the areas now under cultivation, which are almost unlimited. Hitherto, cultivation in its highest sense, as practised at the French and other oyster fisheries, has not been practically instituted, the natural rate of increase of the mollusc being sufficient for present requirements. As shown, however, by the result of the experiments recorded in the Oyster Fisheries Chapter, scientific methods of culture are capable of application to the Queensland oyster, and yield an enormous increase. By utilising the description of spat-collectors described and figured in this volume, it will be possible, also, to bring immensely larger foreshore areas than hitherto under artificial cultivation.

A great desideratum in the further development of the Queensland oyster fisheries, is a solution of the means of bringing her superabundant supplies within easy reach of the British consumer. In its tinned or otherwise conserved condition, the sale and consumption of the bivalve is limited to its utilisation only in a cooked form. As its porterage alive, for the five or six weeks that must intervene between its shipment and delivery in London, is scarcely feasible on a commercially remunerative basis, the only alternative at present available is the refrigerating chamber. An experimental test consignment was placed on board the British India Company's ss. *Jumna* by the Moreton Bay Oyster Company, on the occasion of the author's recent voyage to England, he being deputed to "sample" them *en route* and report on the results. These, it is to be regretted, were scarcely as satisfactory as had been hoped; but at the same time, they justified anticipations that under more favourable, specially arranged, conditions, Queensland oysters may be delivered in prime marketable condition at the London docks. To the innumerable Anglo-Australians, to whom the flavour of the Queensland or Sydney Rock oyster, as it is variously known, is held in higher repute than even the Colchester native, the prospects of a regular supply of the Antipodean bivalve would be welcome intelligence.

The potentialities of the pearl and pearl-shell fisheries of the Great Barrier region represent, in the author's opinion, one of Queensland's most valuable assets; the direction in which this fishery is capable of unlimited development is, as with the oyster fisheries, that of artificial cultivation. In the chapter dealing with the pearl-shell industry, the feasibility of transporting the mother-of-pearl shell and of cultivating it, much after the manner of ordinary oysters, is, by the record of practical experiment, fully demonstrated. Foreshore areas and reef-lagoons throughout Torres Strait and the Great Barrier region, to the extent of thousands of square miles, thus opened up for profitable development, represent, in consideration of the leasing powers over these areas now possessed by the Government, as established by the recent Act, an enormous potential source of revenue.

Several important points are associated with the leasing capacities possessed by the Queensland Government. The territorial boundary of Queensland, as defined by Act 43 Vict., No. 1, 1879 (quoted *in extenso* on page 224), is conterminous with the outer border of the Great Barrier Reef,

extends to the north-east angle of Torres Strait so as to include Bramble Cay, and touches the New Guinea coast at the Baxter River. From this point it trends in a slightly south-westerly direction, until it reaches the parallel of longitude of 138° E., intersecting the Gulf of Carpentaria ; it is thence continuous with that parallel until it gains the mainland, little over one degree west of the Wellesley Islands group. Queensland, by virtue of the Federal Council Pearl-shell and Bêche-de-mer Fisheries (Extra-territorial) Act of the year 1888, is empowered to exercise legislative control over all vessels, under the British flag, fishing within the boundary as above defined ; such control comprising the very necessary police supervision, and the levying of such licenses and duties as may be required for the purposes of revenue and efficient administration.

The question has been raised, with relation to this Act, as to the extent of the powers possessed by the Government to grant leases of the banks, reefs, and foreshores, within the territorial boundary, for the purpose of the collection or cultivation of the commercial marine products of this extensive district. In response to a formal interrogation on this subject addressed to the Colonial Office, Lord Carnarvon declared, in a despatch dated April 5th, 1875, that the Government could not legally claim leasing rights with respect to any waters lying outside the internationally-recognised three miles limit, from low water mark, of any mainland or island contained within the territorial boundary. This declaration, while conceding immense possibilities, in association with the Queensland mainland and the innumerable coral islets of the Great Barrier and Torres Strait Archipelagoes, is by no means as comprehensive as could be desired. It at the same time serves to emphasise the very dubious and unsatisfactory state of international law as it now exists, with relation to the fishery industries of the world.

The growing tendency of the age is to regard coastal fisheries as the natural and valuable asset of the country with which they are conterminous. If this principle could be generally recognised and agreed upon, the several vexatious international fishery disputes which have recently agitated the minds of many nations might be peaceably adjusted. On the bases and principles on which fishing operations are conducted at the present day, a wider latitude of action than the three-mile limit is demanded, and in some instances it is already tacitly conceded. The pearl and pearl-shell fisheries of Ceylon and Southern India, averaging a distance of from five to fifteen miles from the shore, are controlled by, and dealt with as the exclusive property of, the Indian Government; and to that they bring in a considerable revenue, averaging usually, in such years as the fishery is prosecuted, no less than £50,000. Prior to British occupation, these pearl fisheries were held in possession by the Dutch Government, and at a still earlier date by the Portuguese. No exception has been taken to the long-established claim of the ruling Government to the exclusive possession of these extra-territorial grounds.

A far more equitable claim might, undoubtedly, be established, by Queensland, to absolute

control over all the semi-submerged Bêche-de-mere yielding reefs and pearl-shelling grounds within the territorial limits of the colony, defined on a previous page ; but yet, on the finding of the Colonial Office, such claim cannot, under present conditions, be recognised. Within reasonable limits, absolute jurisdiction over a more extended area than heretofore, of the fishing grounds contiguous to a country's sea-board, might be made a satisfactory basis for amended international agreement. An extension of the present three-mile limit to one of twenty, thirty, or, it might be, as much even as fifty miles from the mainland or island foreshore, might be agreed upon as a settlement of several of the most vexatious existing fisheries-jurisdiction disputes.

In anticipation of the sitting, or of any future, International Commission's arriving at an adverse decision, with respect to the United States' modest claim to a monopoly of the entire area of the Behring Sea, for the prosecution of her sealing industry, it is suggested that a satisfactory and equitable solution might be proffered in the form of awarding her undisturbed control over a broad band of the sealing grounds that flank the entire littoral of her Alaskan and North-west territories. This band of absolute control should, as proposed in the preceding paragraph, extend to a distance of twenty miles or more from the mainland or territorial islands' foreshores. Somewhat analogous extended limits of jurisdiction might also be reciprocally conceded, with relation to the Canadian and other disputed fishing rights on the Atlantic sea-board. As an essential element in the harmonious adjustment of the strained relationships, that have of recent years characterised the intercourse of the various nationalities in the disputed areas, it is advocated that the community enjoying the monopoly of jurisdiction should, subject to their payment of the appointed license fees and export or import duties, corresponding with those levied on her own shipping, throw open her fishing grounds, unreservedly, to the flags of all nations.

The Australian pearl and pearl-shell fisheries, and similar and allied fishing industries the world over, such as those of sponges, bêche-de-mer, and coral, in which divers are extensively employed, invite the suggestion of a somewhat different plan of treatment. Diving operations with the aid of apparatus have, in Australian waters, so superseded the earlier system of naked diving, that the sea-bottom, within an inside depth of from twenty-five to thirty fathoms, has become practically *terra-firma*, upon which it is possible to prosecute the garnering and cultivation of pearl-shell, sponges, and other valuable marine products, with the same certainty and facilities as pertain to the terrestrial crops. Under such conditions, these submarine harvest-fields represent as substantial and legitimate an appanage as, say, the elevated arable and pasture lands or the subterranean mineral mines of the adjoining mainland. Throughout the sea-boards of these countries, where shallow, cultivable, waters extend for a more or less considerable distance, what might be termed the divers' outside working limit of a depth of thirty fathoms should be made coincident with the actual territorial boundary.

An arrangement on the foregoing basis would give to Queensland absolute control of all the water area within the Great Barrier limits, and also in Torres Strait; though in this latter

instance, as a matter of equity, a half-share of the water area might be claimed by New Guinea. Fortunately, owing to the prompt action taken a few years since by Dr. McIlwraithe, on behalf of Queensland, supported by the voices of the neighbouring colonies, the New Guinea territory, bordering Torres Strait, has fallen within the sphere of British influence. But for this astute politic step, as intricate and vexatious an international fisheries dispute as that of the Behring Sea would sooner or later have inevitably arisen, with regard to Queensland's legal claim to the valuable pearl and pearl-shell fisheries of her northern waters. A limitation of the territorial boundary line to all depths not exceeding thirty fathoms, while leaving Queensland in possession of all the pearl-shell-producing ground bordering the mainland, and around the Wellesley group and other islands in the Gulf of Carpentaria, would release from inclusion in the existing boundary limit, as defined on page 318, an area of some 40,000 square miles in the centre of the district. A similar territorial definition, applied as is here suggested to the extensive pearl-shelling grounds of Western Australia, would, in a like manner, exclude from the existing arbitrary boundary lines a vast area more than one hundred miles from shore, with depths of from over one hundred to as much as three thousand fathoms. The limitation of absolute territorial possession to the practical working depths here suggested, would, finally, deprive objectors to the existing boundary limits of all reasonable cause of dissatisfaction.

Objections to territorial jurisdiction being conceded to the Western Australian Government, over what are practically the high seas, have already taken the shape of a formal appeal to Parliament, and may yet be the subject of international dispute. Writing, however, as the mouthpiece of British subjects, by whom the appeal to Parliament was lodged, Mr. T. H. Haynes, in a pamphlet entitled "International Fisheries Disputes" (Cassell & Co.), declares altogether in favour of the extension of the three-mile to workable diving limits. Concerning this subject, Mr. Haynes writes: "As depth regulates the responsibilities (in the direction of lighting and buoying dangers to navigation), so depth should determine the advantage, by the extension of territorial rights beyond the three-miles limit." And, with reference to the advantages accruing from such extension, he proceeds: "Wherever the diver can reach the bottom, structures can be built up to the surface, where a flag may be hoisted, forts constructed, and shelter and rendezvous for vessels provided; masonry shafts may also be erected, and coal mined from beneath the sea-bed; nurseries for fish may be established, or uses found for new marine products, only to be gathered successfully by divers." Mr. Haynes concludes the section dealing with this subject with a high eulogium on the magnificent gratuitous service to the shipping of the world, rendered by Queensland in the matter of lighting, beaconing, and buoying the intricate Barrier route, and for which all reciprocal advantages in the direction of absolute control of the adjacent waters are, by inference, most abundantly earned.

The potentialities of the Bêche-de-mer fisheries of the Great Barrier district are much akin to those of pearl and pearl-shell. One of the latest of the author's official reports to the Queensland

Government embraced a scheme for the partitioning of the entire area into convenient sections, which should be let on lease, by auction, after the manner of the oyster-grounds in Moreton and Wide Bays. The difficulties raised by the decision of Lord Carnarvon recorded in a preceding page, in the matter of absolute right over the reefs which are only periodically uncovered, at present stand in the way of its complete realisation. A very substantial instalment of the programme suggested might, however, be profitably carried out with relation to the three-mile areas bordering the mainland foreshore, and around every islet and sand-cay of the Barrier system. In the interests of the future welfare and more remunerative development of both the pearl-shell and Bêche-de-mer fisheries, it is highly essential that the Government should have supreme control over the entire fishing grounds. This control should be exercised in the reservation of suitable areas, as Government nurseries for the continual replenishment of the surrounding waters, and in the judicious partition of the remaining areas into free public, and leasehold private, fisheries. Unless some such systematic course of procedure is adopted, the pearl-shell fisheries, particularly, will, in the near future, incur the risk of depletion beyond the limits of profitable working, as has happened in the case of the ordinary oyster fisheries of many countries. This highly unsatisfactory condition of affairs, in point of fact, has already begun to make itself felt on the pearl-shell grounds of Endeavour Strait, and of other formerly prolific in-shore fisheries.

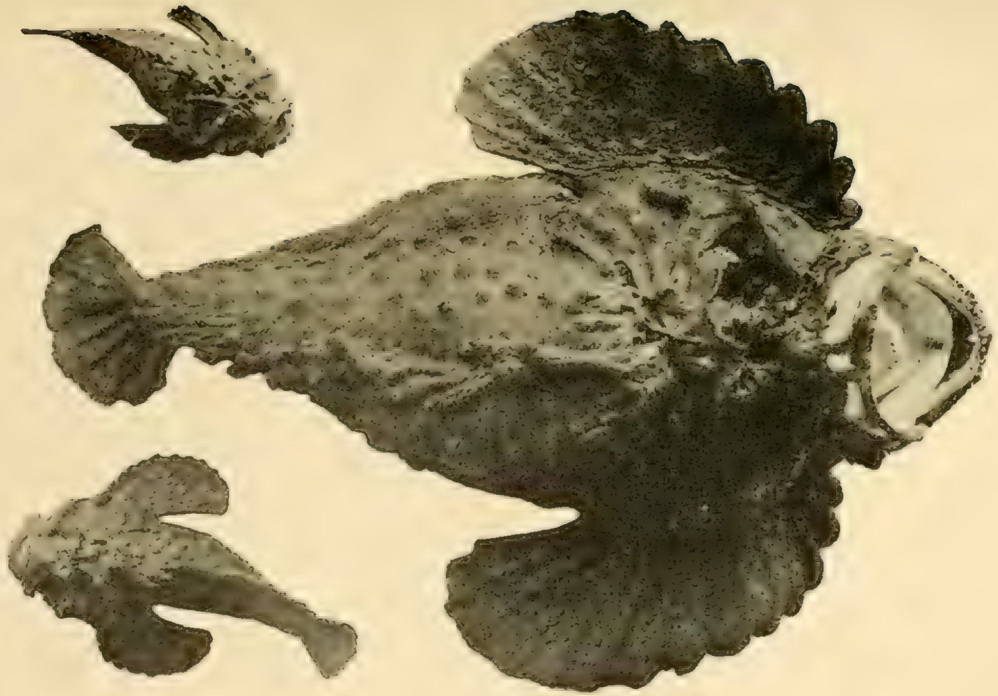
Among the fisheries of the Great Barrier and Torres Strait districts, that are as yet in a relatively latent, or potential, state, those of turtle and tortoise-shell invite brief mention. The edible turtle, *Chelone mydas*, abounds throughout the above-named districts, and breeds extensively on the sandy shores of the coral-cays and islets. Except, however, for local consumption, and for the export of a limited number to Sydney and Melbourne, little or nothing is done with this valuable commercial article. Preserved or dried on the most approved scientific method, Queensland turtle should find an extensive market both in Europe and China; for in the latter country, more particularly, every description of dried fish or allied product finds a ready sale. Unprecedented natural facilities, moreover, exist, at numberless stations within the precincts of the Barrier, for the institution of large turtle-breeding ponds and lagoons, that might equal in importance the celebrated establishment in the island of Ascension.

A method frequently employed by the natives of Torres Strait to capture turtle is remarkable. The large sucking-fish, *Echeneis naucrates*, which grows to a length of three or four feet, and is distinguished by the natives by the title of "Gapu," is pressed into the service. The fish is kept alive in water in the bottom of the native canoe, a thin line being fastened round its tail and through its gills. On a turtle being sighted in the vicinity of the canoe, the sucking-fish is thrown out towards it, and immediately swims to and fastens upon its carapace. If the turtle is of small or medium size, it is hauled in by the line, the fish retaining its tenacious hold; but if it be a large one, a native jumps overboard with a stronger line, and, following the smaller one down, secures the reptile.

A valuable tortoise-shell producing turtle is also plentiful in the Barrier district, but as yet the trade in tortoise-shell from this region is not sufficient to constitute an independent industry, the greater portion of that which is collected being obtained in a desultory manner by those engaged in curing Bêche-de-mer. The average annual value of this material exported from Queensland within the past ten years has slightly exceeded £400. A higher figure, and one that indicates that the trade in tortoise-shell is increasing, was, however, reached in the year 1889, when it amounted to as much as £1,705. The prices obtained for Queensland tortoise-shell vary considerably, according to quality. The best and most valuable description is obtained from the true tortoise-shell or hawksbill turtle, *Chelone imbricata*, which, if of superior texture, may realise from £1 to £1 5s. per pound. The thin and inferior descriptions of tortoise-shell produced by the edible turtle, *Chelone mydas*, will not obtain a higher price than 4s. or 5s. per pound. There is every reason for believing that the tortoise-shell turtle might, in common with the green species, be made a subject of cultivation.

Among the more intelligent of the Bêche-de-mer fishermen, as many as five distinct Barrier Reef varieties of turtle are recognised: these are the loggerhead, *Thalassochelys caretta*, the ordinary green edible species, the tortoise-shell turtle, and a red- and a yellow-backed description. This last-named, or yellow-backed, form would appear to be a melanotic variety only of the hawksbill; the shell is yellow throughout, and is so highly prized that as much as £20 per pound has been offered for it to the fishermen. The red-backed turtle would seem, in a similar manner, to be a variety only of the ordinary edible species. All these Barrier Reef turtles, with the exception of the loggerhead, are esteemed for food. The circumstance that the loggerhead is essentially a fish-eating species, while the other varieties feed chiefly on seaweeds, will account for its rank qualities.

While concerned with turtles, a suitable opportunity is presented of redeeming the promise made on page 101 of introducing the reader to the Great Barrier sea-serpent. The monster, in this instance, must be relegated, if anywhere, to the order of the Chelonia, or Shield-reptiles, which includes the turtles, tortoises, and terrapins; but it possesses, as in all sea-serpents hitherto described, unique individual peculiarities. Hopeful anticipations were entertained by the author that Dr. A. C. Oudeman's long promised and recently published treatise on the great sea-serpent would have yielded some corroborative evidence respecting the sea-serpentine chelonian. The only instance, however, in which the presentment of a gigantic turtle is identified with the so-called sea-serpent, is that of the animal reported by the officers of the Royal yacht *Osborne* as having been seen by them on June 2nd, 1877, off the coast of Scilly. The figure reproduced on page 349 of Dr. Oudeman's work, appeared in *The Graphic* of June 30th of that year. This turtle-like monster, having a back about fifteen feet broad, flippers of the same length, and a head about six feet thick, Dr. Oudeman claims to belong to the pinnipedia, or the seal and sea-lion tribe. His only other reference to the turtle group, p. 423, is to dismiss it, in



1. STONE FISH. *Synancidium horridum*, ½.

2. BANDED GAR-FISH. *Hemirhamphus far*, ½.

3. WHITE TREVALLY. *Caranx nobilis*, ½.

4. BANDED DOREY.
Scatophagus ætate-varians, [illegible]

5. PIKE EEL. *Muraenesox cinereus*, ½.

W. Saville-Kent, Photo.

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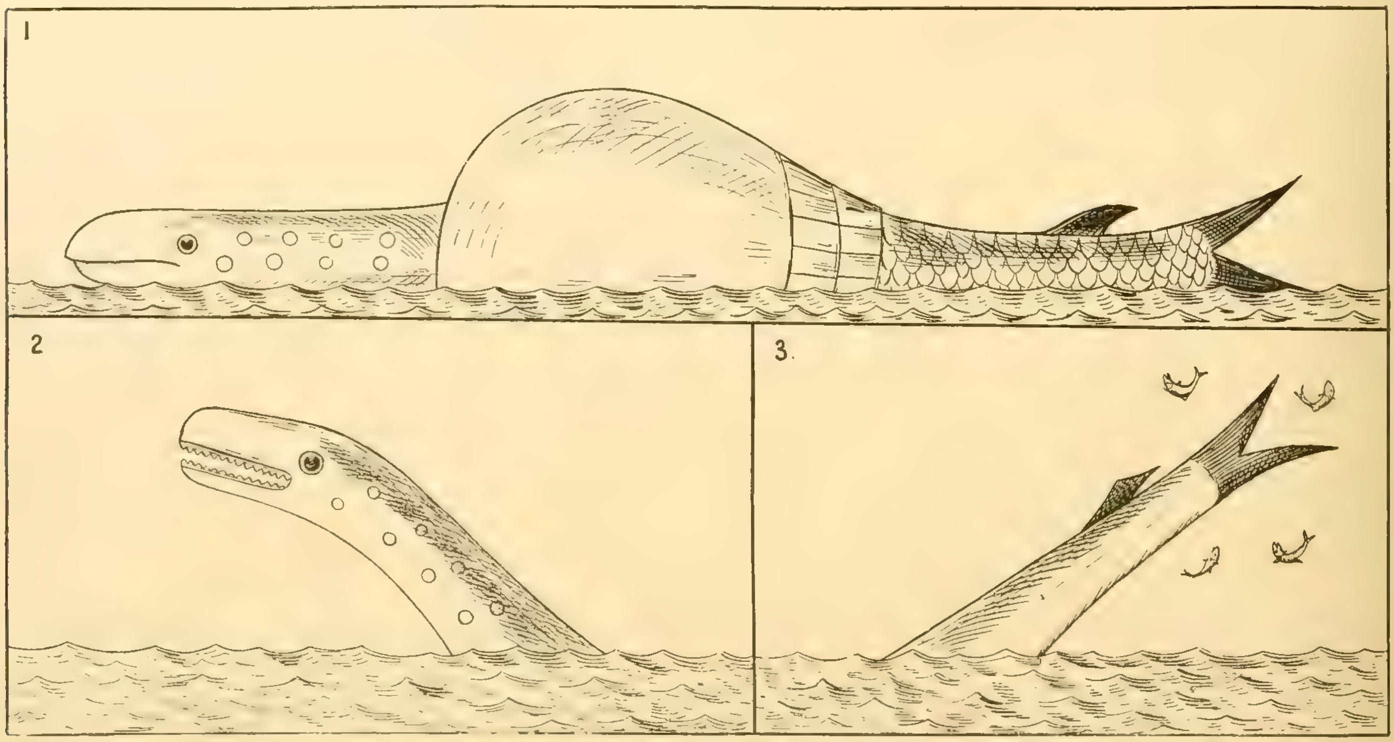
company with that of the crocodilia, from serious consideration, as including a possible representative of the mystic animal.

The discoverer of the latest, Queensland, edition of the sea-serpent is a lady, Miss Lovell, who has for many years past officiated as school-board mistress to the Sandy Island Lighthouse community. She takes a keen interest in all local natural history matters, and has recorded in the Queensland newspapers, and elsewhere, many data of importance relating thereto. By way of introduction to Miss Lovell's little "find," it may be mentioned that it is tolerably well known to the aboriginals of Great Sandy or Fraser's Islands, and is associated by them, after the manner of native nomenclature, with a double-barrelled name, which takes in this instance the euphonious form of the "Moha-Moha." The Moha-Moha is, from its chronicler's description, a most amiable and peacefully-disposed representative of the sea-serpent tribe, and the one, evidently, that we may look forward in the near future to seeing acclimatised in an aquarium or zoological garden, or, it may be, economically utilised as the chief ingredient—it will always be too scarce to use pure and unadulterated—of a new and alderman-enthralling brand of turtle soup. A "tall" price, as presently related, has already been set upon the creature's head by the high priests of science, and the supply as yet falls so far short of the demand, that it will consequently be some little while before "Moha-Moha" soup is inscribed on the daily menu of our city restaurants. It is essential that the Queensland brand-new, soup-potential, species should possess "a local habitation and a name" that shall separate it decisively from the common herd of sea-serpents that have already had their day. With reference to its obviously-combined chelonian and saurian peculiarities (*cf. infra*), coupled with a fitting acknowledgment of its discoverer, it is here distinguished as the Great Barrier sea-serpent, *Chelosauria Lovelli.*

Considered seriously, the existence of certain Chelonia which combine the popularly familiar characters of chelonians and saurians is well known; for example, the singular alligator terrapin, *Chelydra serpentina*, of North America, while bearing a relatively rudimentary carapace and the horny jaws of a chelonian, has short clawed limbs, and a long, bulky, serrated tail like that of an alligator. As related by Miss Lovell, the Moha-Moha, according to the natives, possesses feet like an alligator, and is, in such case, referable to the tortoise and terrapin, and not to the turtle, section of the chelonians. The mouth armature, represented in Miss Lovell's sketch by distinct dentition, is, moreover, remarkably saurian in its aspect. The one anomaly in the sea-serpent's morphology is its tail, which is delineated as distinctly forked, and with bony rays, as in an ordinary fish. The author hoped, by obtaining a detailed description of the creature direct from its original observer, to have been in a position to give a more satisfactory account of this appendage. No more explicit data, however, than are here recorded were forthcoming; and the only explanation that can be suggested with relation to it is that it is actually a bifurcated fleshy tail, or possibly an originally spatulate or paddle-like one, at which a shark, or perhaps a cross-grained, back-biting relation, had taken an unfriendly nibble.

Miss Lovell's drawings and description of the Moha-Moha are herewith reproduced. A very slight deviation from the original sketch has been made in Fig. 3, a few average sized fishes being introduced to scale, as thrown up into the air on the monster's raising its tail, as described in Miss Lovell's narrative, and with the object of conveying some idea of the creature's proportions.



THE MOHA-MOHA, OR GREAT BARRIER REEF "SEA-SERPENT," CHELOSAURIA LOVELLI.

Fig. 1.—The animal lying prone in shallow water.

Fig. 2.—The animal with head reared above the water, the body and tail being submerged.

Fig. 3.—The tail raised above water, and by its action scattering a shoal of fishes.

"I was (while walking on the Sandy Island beach) admiring the stillness of the sea, it being a dead calm, when my eye caught sight of the head and neck of a creature I had never seen before. I went to the edge of the water and saw a huge animal, lying at full length, which was not at all disturbed by my close proximity to it, enabling me to observe the glossy skin of the head and neck, smooth and shiny as satin. Its great mouth was wide open all the time it was out of the water. In about a quarter of an hour or so it put its head and neck slowly into the sea, closing its jaws as it did so. I then saw what a long neck it had, as it moved round in a half circle, and also perceived that the head and neck were moving under a carapace. When the head was pointing out to sea it rose up, putting a long wedge-shaped fish-like tail out of the water over the dry shore, parallel to myself, and not

more than five feet from me, not touching the sand, but elevated. I could have stood under the 'flukes of its tail.'

"The only part of the body that had marks like joints (like in size and shape to a common brick) was also on the dry shore, but *resting* on the sand; the great dome-shaped carapace, dull slate-grey, was standing quite five feet high, and so hid its long neck and head from my view, which before it rose I could see as a long shadow in the water. The carapace was smooth and without marks of any sort. The fish-like part of the tail was as glossy and shiny as the head and neck, but of a beautiful silver-grey, shading to white, with either markings or large scales, each bordered with a ridge of white, but if scales, not like those of a fish in position, as the fishes' scales lie horizontally, whilst the Moha's, if scales, lie perpendicularly, each the size of a man's thumb-nail. It had a thick fleshy fin near the end, about three feet from the flukes, and, like them, chocolate-brown. The flukes were semi-transparent; I could see the sun shining through them, showing all the bones very forked. One of the girls asked me if a shark had bitten a piece out of its tail, and the other one wanted to know if I thought it was an alligator! The fish-like part was quite twelve feet long.

"All the time the animal was on shore it was perfectly motionless; at last it gave a curious half-twist to the fluke part of its tail, the movement only reaching just beyond the fleshy fin, and, without disturbing the water in the slightest degree, vanished. I seemed only to have taken one breath when I saw its tail out of the water about the place where the steamer anchors, sending a quantity of fish into the air. I then saw it give a twist of its tail and it disappeared altogether. The black boy saw it on shore the previous Monday, the 9th inst. As I was so close to it for at least half an hour, I was able to study its shape and colouring. In moving about, head and tail were seen alternately above water, but not even the shadow of its great body, and, from the length of that, a spectator could not guess that the head and tail belonged to the same creature, particularly as the colouring is so different. The parts I did not see were the legs. I stooped down and tried, but in vain, to see them, though the Moha was only standing in a foot of water, but the Black described them as being like an alligator. I wrote to Dr. Ramsay (Sydney) to ask if the Moha was the same creature as the great turtle of New Guinea, of which the Sydney Museum possesses a skeleton, but he said in reply that it was quite unlike, and calls the Moha a tortoise, which I think is correct. Dr. Günther (of the British, Natural History, Museum) would give £100 for the entire animal, £50 for part, and a fair price for the head and neck sun-dried."

In reply to the author's application to Miss Lovell for the fullest information, and, if possible, corroborative testimony concerning the appearance of this remarkable creature, he was furnished with the foregoing account; and, in addition, with a document setting forth that it had been seen by seven white people and a black youth either on the same occasion, or within a few days' interval of the time that Miss Lovell saw and sketched it on the beach. The signed testimony is as follows:—

"We, the undersigned, saw the Moha-Moha (as described by Miss Lovell) making for the shore of Sandy Cape on June 8th, 1890:

"James Alsbury, 1st assistant, Sandy Cape Lighthouse.

"William H. Lees, 3rd assistant, Sandy Cape Lighthouse.

"Mrs. Lees.

"Donald Henderson.

"Jemima Alsbury
"Jessie Alsbury } daughters of James Alsbury."

Robert, the black boy, sets his "mark" against it, it having been seen by him on the shore on the previous Monday. The two girls, Jemima and Jessie Alsbury, and the black boy, were present on the shore, having gone down there previously, when Miss Lovell interviewed the monster, the former, as mentioned in the narrative, addressing to her a pertinent question concerning the contour of the creature's tail.

Concerning the Barrier Reef "sea-serpent," it is desirable to mention that full publicity was given to Miss Lovell's narrative in the contemporary newspapers, and that a somewhat distorted drawing and description of the animal appeared in *Land and Water* of January 3rd, 1891. In commenting on it, the Editor suggests that the creature seen was probably "the Carettochelys, a monster turtle known to exist at the mouth of the Fly River, New Guinea."

On referring to the original account of this New Guinea chelonian, recorded by Dr. E. P. Ramsay in the Proceedings of the Linnæan Society of New South Wales for the year 1886, the author finds that, while possessing certain peculiar anatomical features, it exhibits no excess in size that indicates its affinity with Miss Lovell's species. The dimensions of *Carettochelys insculptus*, as given by Dr. Ramsay, are, in point of fact, considerably smaller than those of an ordinary turtle, its total length not exceeding thirty inches.

In a later issue of *Land and Water*, April 25th, 1891, a correction of the previous description, with additional details of the monster, is contributed by Miss Lovell. This latter is supplemented by a further editorial comment, in which reference is made to "a large and fierce variety of turtle belonging to the genus 'Triolix,' which is well-known to inhabit Queensland, and to occasionally attack men." The possibility of Miss Lovell's Moha-Moha being a species of "Triolix" is suggested in association with this editorial criticism. The author has been unable to find any such generic name authentically employed in chelonian terminology, but anticipates the word is a misprint for Trionyx. Chelonia of other genera (Chelodina and Emydura) occur in the fresh waters of Australia. While these may be long necked (ex. *Chelodina longicollis*), they are by no means of large size, and, though exhibiting a certain amount of defensive pugnacity when captured, they can scarcely be styled ferocious, man-attacking species.

Among independent testimony concerning the apparent existence of a gigantic long-necked chelonian in Australian waters, the author may mention that his attention has been directed by

Mr. Arthur Garrick—brother to Sir James Garrick, the Queensland Agent General—to the circumstance that a very large long-necked species, which may protrude its head at least five or six feet above the surface of the water, is familiar to fishermen in the neighbourhood of Port Jackson, and was on one occasion seen by the author's informant.

A highly characteristic Barrier Reef animal, that possesses some existing and probably a yet more considerable latent value, is the Australian dugong, *Halicore australis.* It is met with, in more or less abundance, from Moreton Bay throughout the Barrier to Torres Strait. In aspect it somewhat resembles a porpoise or other cetacean, having a smooth, subcylindrical body, a broadly-flattened tail, two anterior flippers, and atrophied hind-limbs. It possesses, however, no dorsal fin, while the head, compared with that of a porpoise, has a distinctly rounded muzzle, and the mouth in the male is armed with projecting tusk-like incisors. The dugong is technically referred to a distinct herbivorous order of the Mammalia known as the Sirenia, which includes, in addition to a Red Sea and Indian member of the same genus, the better known Manatee, Manatus, of the South American and African rivers. Within historic times a much larger representative of the same family, *Rhytina Stelleri,* attaining to a length of from twenty to twenty-five feet, lived in Behring Sea and other areas of the North Pacific. The last surviving specimen of its race is generally supposed to have been killed in the year 1768. The food of the Australian dugong consists almost exclusively of the Zostera-like marine grass, *Posidonia australis,* which is developed in great abundance throughout the reef-flats of the inter-tropical coast-line.

The habits of the dugong are essentially social, the animals assembling in herds, of from half-a-dozen to thirty or forty or more individuals, the females being always much more numerous than the males. The average length of the adult is from eight to ten feet, but it occasionally attains to as much as twelve feet. The young are produced singly, at varying periods of the year. The mother dugong, when nursing her young, is in the habit of raising herself erect in the water, and at such times presents a remote resemblance to a human being. It has been conjectured that the dugong seen under such conditions gave rise to the legendary stories of the existence of mermaids. A characteristic illustration of dugongs thus engaged, from Sir Emerson Tennent's "Ceylon," is reproduced on page 310. The danger that was threatened, of the animal becoming exterminated in the districts of Moreton and Wide Bays, through over-fishing, has been happily averted; the Government having taken the precaution to institute a prolonged close season whenever it appears—from the reports of the Fisheries Inspectors—that the herds are becoming too sensibly diminished.

The chief value of the dugong is associated with the oil it yields. A few years since it obtained, for medicinal purposes, a first-hand price of £1 per gallon; recently it has receded to as low as twelve shillings, and the fishing is in consequence not nearly so remunerative. The flesh is highly prized by the natives throughout the area of its distribution on the Australian coast.

It is also much appreciated by many Europeans, especially at the outlying Barrier and Torres Strait fishing stations, where it is commonly cured and used as "bacon."

The capture of the dugong is conducted on distinct principles, in different parts of the Queensland coast-line. In Moreton and Wide Bays, nets of great strength, having a mesh of a yard's width, when measured diagonally from knot to knot, or eighteen inches on the square, are stretched, at night, across the tracks the herds are wont to follow to their pasture-grounds. A little further north, at Repulse Bay, just above Mackay, a systematic dugong fishery is prosecuted by a European, with the exclusive aid of the mainland aborigines. The method of capture and other details associated with this fishing, related to the author by the proprietor of the station, may be appropriately recorded. The natives pursue the animals, moonlight nights being most favourable, in their frail bark canoes, with heavy dugong harpoons, to which long lines are attached. Two men are included in one canoe, the business of one being to keep a look out for dugong, while the other bails the cranky boat. The endeavour, in the first instance, is to spear the animal through its fleshy tail, whereupon it is apt to twist itself up, and get entangled in the line. A second spear is then thrust through its muzzle, which stops its breathing, and thus the animal is speedily suffocated and dispatched. The price, or value in goods, paid by the station proprietor to the natives for each dugong captured, is five shillings; but of these the purchaser only requires the oil-producing livers, and the hides, bones, and teeth, leaving the natives the carcases to feast upon. The hides, if well-cured, realise a price of $4\frac{1}{2}$d. per lb., the large tusks of the male about half-a-crown per pair, while the bones make the best charcoal for sugar refining. The price realised for the oil, as previously recorded, ranges from 12s. to 20s. per gallon. After many years' experience, it has been found at the Repulse Bay station that the old cows yield the most oil, the quantity being sometimes as much as eight or ten gallons, but on the average only four or five. The winter months, with respect to the amount of oil obtained, are the most profitable ones for the prosecution of this fishery.

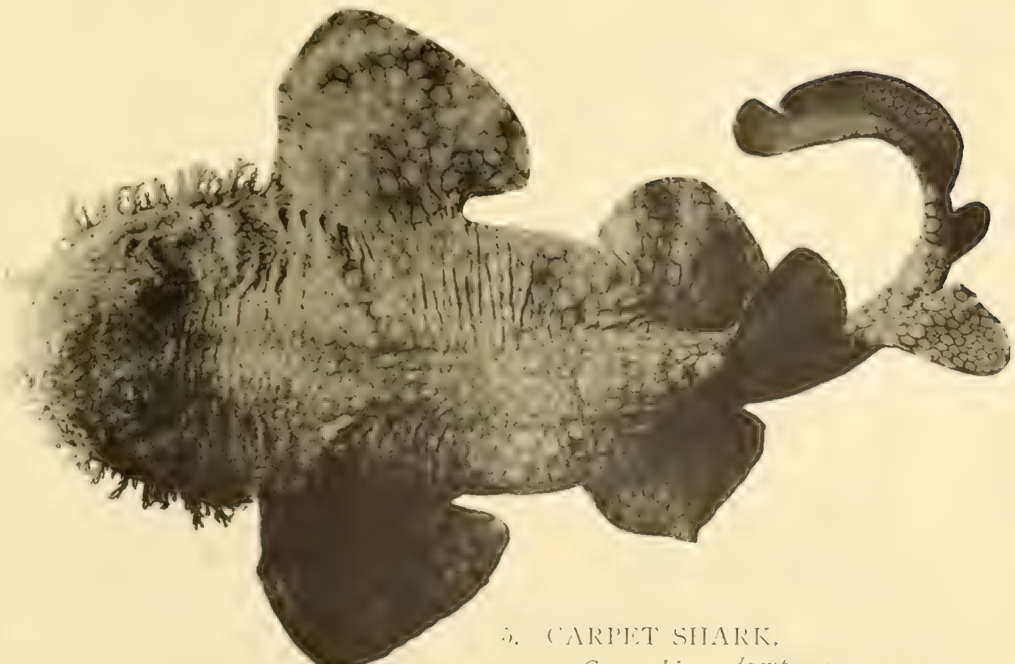
In the more northern districts of the Barrier, and in Torres Strait, the dugong does not form the subject of a systematic fishery, with a view to export trade in its hide and oil, but is killed almost exclusively by the natives for the supply of their commissariat. It is most commonly speared from a canoe, or, in Torres Strait more particularly, from a light wooden staging that is temporarily erected, where the animals have been observed to repair to feed. The dugong spear used in Torres Strait is a formidable weapon, being, as originally described by Macgillivray and more recently by Professor Haddon, a pole from twelve to fifteen or more feet in length, with its butt-end club-shaped and hollowed for the reception of a loose-fitting barbed dart, to which the long line is attached. The opposite end of the shaft is usually perforated, and decorated with tufts of cassowary feathers, ovula-shells, or rattling seed-pods.

The author is enabled to reproduce, through the courtesy of Professor A. C. Haddon, a most excellent photograph, taken by him, of a Torres Strait, Jervis Island, native, armed with the

1. POUCHED LEATHER-JACKET.
Monacanthus sp., $\frac{1}{3}$.

2, 3. OX-RAY. *Dicerobatis eregoodoo*, $\frac{1}{50}$.

4. SHOVEL-NOSED SKATE.
Rhinobatus granulatus, $\frac{1}{10}$.



5. CARPET SHARK.
Crossorhinus dasypogon, [illegible].

W. Saville-Kent, Photo.

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characteristic spear, or "wap," and in proud possession of two recently slaughtered dugong. The larger of the two is a full-grown male, and the smaller one a young female.

We may appropriately incorporate with this picture a description of the methods of taking the dugong, obtained by Professor Haddon from native sources, and included by him in his "Ethnography of the Western Tribes of Torres Strait." Referring first to the method of capturing it from a boat, he writes as follows:—

"When close enough, the man bearing the spear jumps into the water, at the same time harpooning the dugong as it is in the act of breathing. The latter immediately dives down, and runs out the rope which is fastened to the dart, the man having to be careful not to get his head

NATIVE CHIEF, NOMOA, OF JERVIS ISLAND, MABUIAG, ARMED WITH LONG SPEAR, OR "WAP," WITH WHICH HE KILLED THE TWO PROSTRATE DUGONG.

(Reproduced from a photograph by Professor A. C. Haddon.)

entangled in the loops of the rope, as deaths have occurred from this accident. The man returns with the spear-shaft to the canoe. Other men immediately dive into the water, and when the dugong once more rises to breathe they tie a second rope round its tail, and then, whenever it attempts to rise, the men, by diving at the same time, pull it down with the rope, and in a very short time suffocate the unwieldy animal. So far as I know, death always occurs through asphyxia. Owing to the thickness of the skin and blubber, and the shortness of its point, the

dart can never penetrate to a vital organ, unless it should happen to pierce the spinal cord. At the present time the dugong is almost invariably speared from luggers, as these vessels are so much more convenient to handle than canoes.

"The stage, or '*neet*,' is only employed on moonlight nights. A man would walk on the reefs at low tide in the daytime, to watch for traces of the dugong. When he found a patch of 'dugong grass' which had been partially browsed, he would erect the staging there, knowing that the dugong would repair nightly to the same spot until the fodder was exhausted. The stage was constructed of six bamboo poles lashed together, surmounted by the steering-board of the canoe; and on this the rope was coiled and the spear put in readiness; and all night the man would perch on this board awaiting the arrival of the dugong. When it approached sufficiently near it was speared as above. Usually a wooden or stone image of a dugong would be slung on the neet, to serve as a charm to ensure the approach of the animal."

The subject of Worms is not, at first sight, one fraught with great possibilities. Mr. Darwin, however, has shown that their latent potentialities are sufficiently considerable to furnish the worthy theme for an immortal volume. Brief reference has also been made in a previous chapter to a Tasmanian worm, *Magascolides Tasmanicus*, of such magnificent proportions—a length of three or four feet, with a diameter of an inch or more—that it would, seemingly, possess substantial economic properties. These worms, however, are scarcely eligible, as their dimensions might deceptively suggest, for relegation to the cuisine, or for presentation at the luncheon or breakfast-table in the form of sausages or stewed eels; their substantiality, when put to the test, consisting, as it were, of a mere sausage-skin crammed full of their native soil. The only satisfaction, in point of fact, that the author was able to extract from specimens sent him from a Tasmanian, Ringarooma, district, was the enjoyment of their society in lieu, say, of that of a dog or of a cat, during a constitutional stroll at early morn or dewy eve on the homely grass-plot. Worms, nevertheless, in far-off Fiji and the neighbouring districts, represent one of the most appetising gastronomic delicacies, and the signs are not altogether wanting that the Great Barrier region can produce its own choice brand of the same dainty. The worm alluded to in this connection is, of necessity, the famous "Palolo," *Palola viridis*, probably not unknown to many Australians; and with respect to the phenomena that attend its appearance and its method of capture, the following brief account may be given, in introduction to the discussion of its Barrier Reef representative.

"The delicacy known as *Palolo* is a small marine worm, allied to the genus *Nereis*, that at a certain season of the year appears in vast shoals on the surface of the sea in the vicinity of Samoa, Tonga, Fiji, and other of the Pacific islands. It is regarded by the natives as one of the daintiest luxuries their territories produce. The epoch of the Palolos' appearance is reported to be confined to two days only in the months of October and November, these being the day before, and the day upon which, the moon enters the last quarter. In anticipation of the forthcoming

feast, the natives assemble in numbers the night previously, at the localities among the reefs where *Palolo* is obtained most abundantly. At dawn of day—the proverb of the early bird and the worm must have originated in Polynesia—the worms make their appearance in countless myriads, sport on the surface of the water for two or three hours, and then mysteriously disappear. On the second morning they appear in even greater quantities than on the first one, and are ladled into the canoes with the hands, nets, baskets, bowls, or other available utensils. They are eaten, both raw and tied up in bread-fruit leaves and baked; while large quantities are sent inland by way of barter, or as presents to those who are unable to take part in the fishery."

The author is by no means beyond hope that Palolo may become a standard Queensland dish. Soon after daybreak on one of the reefs at Thursday Island, the author witnessed, in October, 1889, an assemblage of nereids on the surface of the water which, though of somewhat smaller size, resembled in form, and manifested all the peculiar movements of, the Palolo. In like manner, they also within a few hours entirely disappeared from view. By a close examination of the worms disporting on the surface of the water, and also, when isolated in suitable receptacles, and with the aid of the microscope, the author succeeded in discovering the *raison d'être* of their early revels. It was, in fact, the nereids' public wedding morning, and these their wedding junkettings. Each worm was laden with ova or milt, which were discharged in little thin milky streams, one from each side of the body, as they swam through the water. The reproductive elements, commingling under these conditions, effected fertilisation after the manner of the spawn of certain fishes, such as say the Gadidæ or cod tribe. It may thus be assumed that the periodical appearance of the Polynesian Palolo on the surface of the water is similarly associated with the animal's propagation. Concerning the Thursday Island variety, it is a subject well worthy of further investigation from both a scientific and a gastronomic view. Presuming a happy combination of the two, we may look forward, in the not very distant future, to a nineteenth or twentieth century revival of the "Diet of Worms" at the proposed Thursday Island Zoological Station, which shall be annually discussed by the Ministry of North Queensland, or at more remote intervals by the Federal Council, with all the dignity and decorum of a Greenwich whitebait dinner.

A potentiality which undoubtedly exists, but which has hitherto lain entirely fallow, throughout the length and breadth of the Great Barrier area, is associated with the collection and cultivation of commercial sponges. Sponges of excellent quality have been obtained by the author at innumerable points, from the Capricorn Islands group to Torres Strait, and could no doubt be profitably collected throughout the greater portion of the intervening areas. A sample collection brought to England and compared with the extensive series of named types contained in the British (Natural History) Museum, has been found to contain no less than six varieties, to all external appearance indistinguishable in quality and texture from the most valuable market species. These include three fine toilet-sponges, *Euspongia officinalis*, var. *mollissima* and var. *punctata* as

obtained from the Mediterranean, and a third variety of the same specific form, corresponding more nearly with the so-called "glove-sponge" of the Bahama seas. The remaining three samples are apparently referable to the more porous bath-sponges, represented by the genus Hippospongia, in all respects identical with the Mediterranean *Hippospongia equina, H. equina,* var. *meandrinæformis,* and *H. gossypina.*

The neighbourhoods of the Claremont and Piper lightships have been mentioned in a preceding chapter, as localities whence fine-textured sponges have been gathered; but there is hardly a coral-island beach throughout the Barrier district from which they may not be collected in an eroded, washed-up, state, indicating the existence of their natural beds in the near vicinity. In this cast-up condition, the fibre of the sponges is usually much weathered and decayed, and very rarely sufficiently well preserved for domestic use. Sponges, for trade purposes, must be gathered fresh, and be systematically treated. The method most commonly employed is to place them in bulk in a small staked-in inclosure, called a "crawl," on a spot of the seashore, where, while submerged and washed by the waves with each returning tide, they may be at low water exposed to atmospheric influence. During these latter intervals they are likewise beaten with sticks, in order to get rid of their glairy animal matter. When this is completely eliminated they are finally washed in clean water, to which a little glycerine is added. This precaution prevents the sponge fibre from getting hard and brittle, as it is especially liable to do in a tropical climate.

Successful experiments have been carried out within recent years, in the direction of transplanting and cultivating sponges in both the Mediterranean and Florida sponge-producing areas; and there is no reason why a similar profitable industry should not be established in numerous suitable localities within the Barrier limits. The special advantage of the transplanting and cultivating method is, that unshapely and unmarketable sponges, if of the right texture, may be cut up alive into fragments, and each fragment when replanted, will grow in the course of a year or two into a symmetrical marketable sponge. On the author's suggestion, sponges have been specially included in the list of marine products for which, in accordance with the new Pearl-shell and Bêche-de-mer Fishery Act, 1891, portions of the foreshore and other water areas can now be let on lease by the Queensland Government.

Sponges of a somewhat coarse and inferior description, compared with the species above enumerated, also abound throughout the Barrier district. Many of these could be turned to profitable commercial account at the present day; one of the latest purposes for which similarly coarse sponges are extensively employed being—in a finely shredded state—as a substitute for horsehair, in stuffing furniture.

The valuable potentiality represented by the black coral, *Antipathes abies,* illustrated by Chromo plate XI., Fig. 2, has been already briefly referred to in the coral-descriptive chapter. The species grows abundantly, and to a considerable height and thickness, throughout the inter-tropical Barrier waters; and in consideration of the declining condition of the

formerly prolific fishery for this substance in the Persian Gulf, it is particularly worthy of attention. As previously mentioned, the chief market for black coral is in India, where supplies from a new source would be gladly and remuneratively welcomed. The possibility of finding the precious red coral of commerce, *Corallium rubrum*, or, if not, of successfully introducing and cultivating it within the Barrier limits, represents another potentiality which might be dilated on to a considerable length.

The eligibility of the ordinary reef corals, or Madreporaria, for decorative purposes has been briefly advocated, in association with the descriptive account of the first plate of the photo-mezzotype series, in Chapter I. There is another direction, however, in which these corals, and many other of the marine organisms illustrated in this volume, represent important potentialities. The direction here referred to is that of ornamental design, with relation both to form and colour. For all purposes of decorative art as applied to commercial uses, the coral class furnishes literally a mine of wealth. In whatever associations, such as those of artistic china, tapestries, carpets, wall-papers, and figured materials of every description, wherein plant life, in its natural or conventionalised form, has hitherto been the chief source of design, coral-growths and allied organisms, as represented by Plates I. to X. of the chromo-lithographic series included in this volume, constitute an original and practically inexhaustible field for the exercise of the designer's art.

The reason why this organic group, so rich in patterns of form and colour, has not hitherto been turned to artistic account, is simply explained by the circumstance that the life aspects and living tints of these organisms have, with a few exceptions, been practically unknown. The selection reproduced in this volume is necessarily a very small one, in relation to the wealth of the varieties that remain for choice. At the same time, a single plate in this series, such as Chromo IX., illustrative of the genus Madrepora alone, would furnish the artistic designer with almost endless modifications of colour and contour combinations. The corals delineated by this plate are necessarily only imperfect detached fragments. To minds upon which this suggestion may settle and germinate, it is recommended that an acquaintance be made with the complete specimens exhibited in the Natural History Museum, wherein, though the evanescent life colours have passed away, the characteristic growth contours are represented in their perfected state.

With reference to the more considerable number of the potential subjects dealt with in this chapter, and more especially such as relate to the collection and culture of marine produce, it it scarcely necessary to remark that a number of them might be profitably concurrently developed at judiciously-selected working centres. The localities conspicuously eligible for such industrial operations are the innumerable islets, of both coral and metamorphic formation, that dot the Great Barrier area. Those islands, necessarily, that possess the advantage of permanent water holes are of the greatest value; though, as all lie within the area of a copious periodical rainfall, a

sufficient water-supply can be provided for artificially. A potentiality, as yet latent, pertaining to all these islets, is the growth of the cocoa-nut palm, and the development of the many industries of which this invaluable vegetable product forms the basis. The Queensland Government has recently taken the wise initial step of planting cocoa-nuts on a number of the islands, and, within a few years' time, these will yield an abundant harvest. The luxuriance of the cocoa-nut groves on the mainland as far south as Mackay, and the fact that the tree will perfect its fruit in even the extra-tropical latitude of Moreton Bay, furnish a sure guarantee of the eligibility of the Barrier region for the development of the cocoa-nut-growing industry. Undertaken by public or private enterprise, in combination with one or several of the many existing or potential fishing industries enumerated in this chapter, it would undoubtedly represent an assured and substantial income.

The last, but by no means the least, important of the potentialities which it is proposed to deal briefly with in this chapter, relates to a subject of pure biological science. The Barrier district, throughout its 1,200 miles extent, from Sandy Cape to the New Guinea shores, represents a vast harvest-field ripe for the sickle, wherein, as yet, skilled biological labour is all but unknown. From that harvest-field, the materials brought crudely together in this volume represent, for the most part, but scattered, single-handed, gleanings, culled by the wayside track of official routine. Such as they are, they may be accepted as an earnest of the good things that remain behind, and it is hoped they will stimulate the systematic exploration of this productive region.

Beyond all, it is earnestly advocated, in this day of the establishment of biological stations, at all points of the compass where there appears to be a prospect of good results, that such an institution should be founded at the most eligible spot within the Barrier precincts. The balance of the evidence that can be brought to bear upon this project points most unerringly to Thursday Island. Situated in mid-sea, within easy striking distance of the Queensland mainland, New Guinea, and the innumerable reefs and islands of Torres Strait, and the northern Barrier, it possesses potentialities for the systematic study of tropical marine biology absolutely unequalled. Thursday Island, moreover, notwithstanding its more equatorial location, enjoys a cooler and more salubrious climate than that of the adjacent continent; and constituting, as it does, the port of call for the ships of several lines of ocean-going steamers, it is kept in constant touch with the proceedings of the outside world. The very fact of its having been recently determined to fortify this strategic outpost, and to maintain a permanent garrison there, is a guarantee that Thursday Island now, as compared with earlier days, a long way within the pale of civilisation, can offer almost all the social advantages and conveniences of the mainland cities.

A biological or zoological station established at Thursday Island would be an essentially federal Australian institution, and would look for the main means of its foundation and maintenance to Australian corporate support, and Australian private liberality. In this direction, the science of Marine Biology should not long be disappointed of her hope. The liberal endowment from both of the above sources, which the allied sciences of Mineralogy, Forestry, and

Agriculture already receive, in association with the technical schools and colleges of the Australian peoples, is a guarantee that sooner or later the foundation of the institution here suggested will be an accomplished fact.

Australia is nothing if not practical; and if convinced, as it has been attempted to show in this volume, that her submerged territories are as replete as is the mainland, with potentialities for the acquirement of wealth and distinction, the provision of such a training school, for the acquisition of the necessary practical marine biological knowledge, which would be afforded by an efficiently-equipped Zoological station, should be speedily forthcoming.

The concluding illustration is reproduced from a photograph taken by the author in the Albany Pass. It represents a native fishing party, standing for a moment at attention, after a successful haul. The somewhat remarkable distinctness of the reflections is due to the circumstance that the sun was in the background and almost level with the horizon.

CHROMO PLATE I.

ILLUSTRATING GREAT BARRIER REEF ANEMONES.

CHROMO PLATE I.

ILLUSTRATING THE GREAT BARRIER REEF GIANT ANEMONE.

DISCOSOMA KENTI, N.SP., HADDON, p. 144.

The upper figure represents a small individual of the blue variety, drawn to the natural size, with the tentacular disk folded in a hexagonal pattern.

The two lower figures represent segments of expanded disks of two diversely coloured individuals.

Tentacles of the natural size, representing various individual colorations, are delineated in the two upper corners.

The fish, *Amphiprion percula*, delineated as crossing the two lower figures, is a "commensal" species that inhabits the visceral cavity of the larger specimens of the Discosoma, and utilises it as a harbour of refuge when pursued by its enemies. Natural size.

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BARRIER REEF ANEMONES.

CHROMO PLATE II.

ILLUSTRATING GREAT BARRIER REEF ANEMONES.

CHROMO PLATE II.

ILLUSTRATING THE GREAT BARRIER REEF GIANT ANEMONE.

DISCOSOMA HADDONI, N.SP., pp. 32 and 145.

Segments of the disks, representing about one-sixth only of their entire superficial areas in two diversely coloured polyps, are here delineated, natural size.

Isolated tentacles with their inflated apices, slightly magnified, are represented in lateral view, (thus showing their columnar stalks) near the top and bottom margins of the plate.

The fish, *Amphiprion bicinctus*, in this illustration (having only two white bands) is a commensal with *Discosoma Haddoni*, in the same manner as the three-banded species in the preceding plate is associated with *Discosoma Kenti*.

The Prawn, Palæmon sp., in the right-hand upper corner, also lives commensally within the body-cavity of this anemone, only, however, in individuals that are not tenanted by the fish.

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BARRIER REEF ANEMONES.

CHROMO PLATE III.

GREAT BARRIER REEF ANEMONES AND ZOANTHARIA.

CHROMO PLATE III.

GREAT BARRIER REEF ANEMONES AND ZOANTHARIA.

Fig. 1.—*Palythoa cœsia*, p. 152. Polypary with expanded polyps, natural size.

Fig. 2.—*Rhodactis Howesii*, n.sp., p. 150. Expanded polyp, natural size; 2A, contracted polyp, lateral view; 2B, contracted tentacles, slightly enlarged; 2C, oral area with surrounding, simply capitate, tentacles, slightly enlarged.

Fig. 3.—*Heterodactyla Hemprichii*, p. 147. Expanded polyp, natural size; 3A, 3B, grape-like "nematospheres," enlarged; 3C, portion of the edge of the peristomial border, showing larger palmate tentacles, and intervening clusters of "nematospheres"; 3D, single peripheral palmate tentacle, enlarged.

Fig. 4.—*Acrozoanthus australiœ*, nov. gen., n.sp., p. 153. Upper half of polypary, with polyps in various conditions of expansion, natural size; 4A, portion of dead, hollow, polypary, of thinly chitinous consistence.

Fig. 5.—*Phymanthus muscorum*, p. 149. Expanded polyp, natural size.

Fig. 6.—*Heterodactyla hypnoides*, n.sp., p. 148. Expanded polyp, natural size; 6A, grape-like clusters of nematospheres, slightly enlarged; 6B, isolated pinnatifid tentacles, slightly enlarged.

Fig. 7.—*Cerianthus nobilis*, p. 151. Expanded polyp, protruded for about one quarter of its total length from the aperture of its prostrate, felt-like, dwelling tube, natural size.

Fig. 8.—*Cornularia auricula*, n.sp., pp. 152 and 199. Polypary with expanded polyps, natural size, and a single polyp slightly enlarged.

Figs. 9 and 10.—*Physobrachia Douglasi*, nov. gen., n.sp., p. 150. Expanded polyps, natural size.

Fig. 11.—*Zoanthus Coppingeri*, p. 152. Polypary with expanded polyps, natural size.

Fig. 12.—*Discosoma rubra-oris*, n.sp., p. 151. Expanded polyp, natural size.

Fig. 13.—*Discosoma nummiforme*, p. 150. Expanded polyp, natural size.

GREAT BARRIER REEF ANEMONES.

CHROMO PLATE IV.

GREAT BARRIER REEF CORALS.

CHROMO PLATE IV

GREAT BARRIER REEF CORALS.

Fig. 1.—*Rhipidogyra*, sp. (*? laxa*), p. 158. Natural size. 1A to 1F, modifications of the normally reniform expansions of the tentacle apices, slightly enlarged.

Fig. 2.—*Euphyllia rugosa*, p. 158. Corallum with expanded polyp, natural size.

Figs. 3 to 6.—*Euphyllia glabrescens*, p. 157. Distal ends of corallites, with expanded polyps of diverse colours, natural size.

Fig. 7.—*Pectinia Jardinei*, n.sp., p. 40 and 158. Corallum with expanded polyps, natural size.

Fig. 8.—*Galaxea Esperi*, p. 158. Corallum with expanded polyps, natural size.

Fig. 9.—*Galaxea Esperi*, p. 159. Variety with green and purple polyps, natural size.

Figs. 10, 10A.—*Galaxea*, sp., p. 159. Corallites with expanded polyps, natural size.

Fig. 12.—*Galaxea*, sp., p. 159. Expanded polyps, natural size.

GREAT BARRIER REEF CORALS.

CHROMO PLATE V.

GREAT BARRIER REEF CORALS.

CHROMO PLATE V.

GREAT BARRIER REEF CORALS.

Fig. 1.—*Trachyphyllia amarantus*, p. 161. Portion of corallum, with contracted polyp, natural size; 1A, expanded tentacles of peristomial fringe, slightly enlarged.

Fig. 2.—*Caulastræa distorta*, p. 160. Corallum with expanded polyps, natural size; 2A and 2B, expanded polyps of diverse hues.

Fig. 3.—*Mussa corymbosa*, pp. 19 and 161. Corallites with retracted polyps, natural size; 3A, diagramatic section of expanded polyp, showing lacinulate aspect of tentacular disk; 3B, corallite with contracted polyp, horizontal view.

Fig. 4.—*Mussa multilobata*, p. 161. Corallite with contracted polyp, horizontal view, natural size; 4A, expanded polyps embracing two oral systems.

Fig. 5.—*Prionastræa* sp., p. 163. Corallum with contracted polyps, natural size.

Fig. 6.—*Favia Bowerbanki*, p. 167. Corallum with contracted polyps, natural size.

Fig. 7.—*Cœloria* sp., p. 164. Corallum with contracted polyps, natural size.

Fig. 8.—*Prionastræa* sp., p. 163. Corallum with contracted polyps, natural size.

Fig. 9.—*Moseleya latistellata*, p. 165. An adult and two budding corallites, with retracted polyps, natural size.

Fig. 10.—*Cœloria* sp., p. 164. Corallites with retracted polyps, natural size.

Fig. 11.—*Goniastræa eximia* (appr.), p. 163. Corallum with retracted polyps, natural size.

Figs. 12 and 13.—*Tridacophyllia laciniata*, p. 167. Corallites, with retracted polyps of different tints.

Fig. 14.—*Favia amicorum*, p. 167. Corallum with retracted polyps, natural size.

Figs. 15 and 16.—*Prionastræa robusta*, p. 163. Two coralla with retracted polyps of varying tints, natural size.

Fig. 17.—*Symphyllia sinuosa*, p. 162. Portion of corallum with contracted polyps, natural size.

Figs. 18 and 19.—*Cœloria Esperi*, p. 164. Sage-green and lilac varieties with retracted polyps, natural size; 18A, small area, from base of corallum delineated in Fig. 18, illustrating origin of polyp-valleys from a primary single circular polyp.

Fig. 20.—*Cœloria* sp., p. 164. Portion of corallum with retracted polyps, natural size.

Figs. 21 and 22.—*Goniastræa Grayi*, p. 163. Corallum with retracted polyps, two thirds natural size; 22, expanded polyp, slightly enlarged.

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GREAT BARRIER REEF CORALS.

CHROMO PLATE VI.

GREAT BARRIER REEF CORALS.

CHROMO PLATE VI.

GREAT BARRIER REEF CORALS.

Figs. 1 and 5.—*Plesiastræa Peronii*, p. 166. Coralla with fully-expanded polyps of diverse colours, natural size.

Fig. 2.—*Plesiastræa versipora*, p. 166. Corallum with expanded and contracted polyps, natural size.

Fig. 3.—*Rhodaræa* sp., p. 187. Corallum with expanded and contracted polyps, natural size; 3A, single polyp, horizontal view.

Fig. 4.—*Rhodaræa fruticosa*, n.sp., p. 187, with expanded and contracted polyps, natural size; 4A, horizontal view of isolated polyp.

Figs. 6 and 9.—*Rhodaræa calicularis*, p. 187. Coralla with expanded and contracted polyps, of diverse colours, natural size; 6A and 9A, isolated polyps, slightly enlarged.

Fig. 7.—*Cyphastræa* sp., p. 166. Corallum with expanded and contracted polyps, natural size.

Fig. 8.—*Millepora alcicornis*, p 202. Portion of a corallum with retracted polyps, natural size; 8A, a single polyp system, slightly enlarged; 8B, a polyp system with extended polyps, considerably enlarged (after Moseley); 8C, central nutritive polyp, further enlarged (after Moseley).

Fig. 10.—*Rhodaræa* sp., p. 187. Corallum with polyps expanded and contracted, natural size; 10A, isolated polyp, horizontal view.

Fig. 11.—*Montipora scabricula* (appr.), p. 185. Portion of corallum with contracted polyps, natural size; 11A, isolated polyp, with fully-expanded rudimentary tentacles, considerably enlarged.

Fig. 12.—*Heteropsammia Michelini*, p. 177. Corallum with expanded polyps, natural size.

Fig. 13.—*Fungia crassitentaculata*, p. 173. Fully-expanded polyp, natural size. This figure is a reproduction of the photograph in the Photo-mezzotype plate, No. XXIII., coloured from life. 13A represents a single tentacle of a dark olive-green example.

Fig. 14.—*Fungia crassitentaculata*, p. 173. Two young attached coralla with their associated polyps, springing from a single proliferous stolon or "nurse-stock."

Figs. 15 and 16.—*Cycloseris cyclolites*, p. 176. Corallum, lateral view, with extended tentacles, natural size; 15, oral area, slightly enlarged; 16A, isolated tentacle.

Fig. 17.—*Herpetolitha talpina*, p. 176. Corallum with expanded polyps, natural size; 17A, isolated tentacles, slightly enlarged.

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GREAT BARRIER REEF CORALS.

CHROMO PLATE VII.

GREAT BARRIER REEF CORALS.

CHROMO PLATE VII.

GREAT BARRIER REEF CORALS.

Fig. 1.—*Seriatopora hystrix*, pp. 17 and 171. Corallum with associated polyps, natural size; 1A, terminal branchlet of corallum with expanded polyps, slightly enlarged; 1B and 1C, horizontal and lateral views of an isolated polyp, further enlarged.

Fig. 2.—*Stylopora palmata*, pp. 22 and 172. Corallum with associated polyps, natural size; 2A, B, and C, horizontal and lateral views of expanded polyps, considerably enlarged.

Fig. 3.—*Pocillopora damicornis*, p. 172. Branchlet of corallum, natural size; 3A, B, C, D, horizontal and lateral views of expanded polyps of diverse colours, considerably enlarged.

Fig. 4.—*Oculina fasciculata*, n.sp., p. 170. Branchlet of corallum with expanded polyps, natural size, with a second branchlet to the rear denuded of polyps; 4A, horizontal view of isolated polyp, slightly enlarged.

Fig. 5.—*Echinopora horrida*, p. 170. Extremity of branchlet with the polyps contracted natural size; 5A, horizontal view of isolated polyp with expanded tentacles.

Fig. 6.—*Echinopora rosularia*, p. 170. Portion of corallum with expanded polyps, natural size; 6A, expanded polyp enlarged.

Fig. 7.—*Hydnophora rigida*, p. 169. Branchlet with associated polyps partly expanded, natural size; 7A, small area of the same branchlet, slightly enlarged.

Fig. 8.—*Hydnophora* sp. p. 168. Lateral view of fully expanded polyps; 8A, young polyp possessing only six clavate tentacles.

Fig. 9.—*Merulina ampliata*, p. 168. Fragment of corallum with associated polyps; natural size.

Fig. 10.—*Merulina ampliata*, p. 168. Cream-coloured variety, small area showing oral centres and sparsely scattered tentacles, slightly enlarged.

Fig. 11.—*Lophoseris cristata*, pp. 20 and 176. Fragment of corallum with expanded polyps, natural size; 11A and B, expanded polyps, slightly enlarged.

Fig. 12.—*Hydnophora microcona*, p. 169. Portion of corallum with associated polyps, natural size.

Fig. 13.—*Hydnophora Demidoffi*, p. 169. Pinnacle of corallum with fully expanded polyps, natural size; 13A, isolated polyp with green, retracted, tentacles, enlarged.

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GREAT BARRIER REEF CORALS.

CHROMO PLATE VIII.

GREAT BARRIER REEF CORALS.

CHROMO PLATE VIII.

GREAT BARRIER REEF CORALS.

Fig. 1.—*Dendrophyllia coccinea*, p. 178. Corallum with expanded and contracted polyps, natural size; 1A, expanded polyp, slightly enlarged.

Fig. 2.—*Alveopora clavaria*, p. 186. Portion of corallum with expanded polyps, natural size; 2A, isolated polyp, horizontal view, slightly enlarged.

Fig. 3.—*Alveopora viridis*, p. 186. Corallum with expanded polyps, natural size; 3A, B, C, D, E, F, isolated polyps with tentacles in various conditions of extension.

Fig. 4.—*Dendrophyllia axifuga*, p. 178. Branchlet of corallum with associated polyps, natural size; 4A, isolated polyp, fully expanded, horizontal view.

Fig. 5.—*Montipora foliosa*, p. 184. Portion of corallum with associated polyps, natural size; 5A, isolated polyp, enlarged.

Fig. 6.—*Montipora expansa* (appr.), p. 183. Portion of corallum with associated polyp, natural size; 6A, fragment of the same corallum enlarged, showing polyps in their fullest condition of expansion and in diverse stages of development.

Fig. 7.—*Porites astræoides*, p. 185. Small corallum with associated polyps, natural size; 7A, isolated polyp, enlarged.

Fig. 8.—*Porites divaricata* (appr.), p. 186. Branchlet with associated polyps, natural size; 8A, isolated polyp, lateral view, enlarged.

Fig. 9.—*Porites furcata* (appr.), p. 186. Portion of corallum with associated polyps, natural size; 9A, isolated polyp, enlarged.

Fig. 10.—*Montipora verrucosa*, p. 185. Fragment of corallum with expanded polyps, natural size; 10A, B, isolated polyps, enlarged.

Fig. 11.—*Turbinaria patula*, p. 188. Small corallum, natural size; 11A, isolated polyp, slightly enlarged.

Fig 12.—*Turbinaria peltata*, p. 188. Corallum, slightly reduced; 12A and B, expanded polyps, slightly enlarged.

Fig. 13.—*Astræopora punctifera*, p. 188. Corallum, natural size; 13A, isolated polyp, slightly enlarged.

Fig. 14.—*Turbinaria cinerascens*, p. 188. Fragment of corallum with expanded polyps, natural size; 14A, isolated polyp, enlarged.

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GREAT BARRIER REEF CORALS.

CHROMO PLATE IX.

GREAT BARRIER REEF CORALS.

CHROMO PLATE IX.

GREAT BARRIER REEF CORALS.

Figs. 1 and 2.—*Madrepora prostrata*, p. 182. Fragments of diversely-coloured coralla, natural size; 2A, isolated polyp, enlarged.

Fig. 3.—*Madrepora Kenti*, n.sp., Brook, p. 182. Branchlet, life size and colour.

Fig. 4.—*Madrepora ornata*, n.sp., Brook, pp. 117 and 181. Branchlet, life size and colour.

Fig. 5.—*Madrepora decipiens*, n.sp., Brook, p. 181. Branchlet, life size and colour; 5A, isolated polyp, enlarged.

Fig. 6.—*Madrepora laxa*, pp. 111 and 181. Portion of branch, life size and colour.

Fig. 7.—*Madrepora secunda*, p. 26. Terminal branchlet, life size and colour.

Fig. 8.—*Madrepora grandis*, n.sp., Brook, p. 181. Terminal branchlet, life size and colour.

Figs. 9 and 10.—*Madrepora gemmifera*, n.sp., Brook, p. 183. Branchlets of two diversely-coloured coralla, natural size.

Fig. 11.—*Madrepora Elseyi*, n.sp., Brook, p. 181. Branchlet, life size and colour; 11A, terminal corallites and polyp, enlarged.

Fig. 12.—*Madrepora pulchra*, n.sp., Brook, p. 181. Branchlet, life size and colour; 12A, terminal corallite with expanded polyp, enlarged.

Figs. 13, 14, and 15.—*Madrepora hebes*, pp. 21 and 180. Three diversely-coloured coralla. In Fig. 13 the ground colour has been purposely omitted, to show the expanded polyps; natural size; 13A, isolated polyp of green variety, considerably enlarged.

Fig. 16.—*Madrepora scabrosa*, p. 181. Branchlet, life size and colour; 16A, terminal polyp, enlarged.

Fig. 17.—*Madrepora divaricata*, p. 181. Coalescing branchlets, life size and colour.

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GREAT BARRIER REEF CORALS.

CHROMO PLATE X.

GREAT BARRIER REEF ALCYONARIA.

CHROMO PLATE X.

GREAT BARRIER REEF ALCYONARIA.

Figs. 1-5.—Blue Coral, *Heliopora cœrulea*, p. 194. 1, Branch of corallum, natural size; 2, Expanded polyps; 3, Portion of surface with extended commensal annelids; 4, Transverse section through corallum, slightly enlarged and giving clearer view of commensal annelids; 5, Commensal annelid, *Leucodore*, enlarged, with tentacles retracted.

Figs. 6-8.—Organ-pipe Coral, *Tubipora musica*, p. 191. 6, Portion of corallum with expanded polyps, natural size; 7, Isolated corallites showing connecting platforms; 8 Horizontal view of expanded polyp, enlarged.

Figs. 9, 10.—*Cornularia tubiporoides*, n.sp., p. 199. Polypary with expanded polyps, natural size; 10, Horizontal view of expanded polyp.

Figs. 11, 12.—*Spongodes* sp., p. 196. Diversely-coloured polyparies; 11A, 11B, and 12A, isolated polyps, enlarged.

Fig. 13.—*Xenia elongata*, p. 196. Polypary with expanded polyps, natural size; 13A, isolated polyps, enlarged.

Fig. 14.—*Xenia ochracea*, n.sp., p. 197. Polypary with expanded polyps, natural size; 14A, isolated polyp, enlarged.

Fig. 15.—*Xenia brunnea*, n.sp., p. 198. Polypary with expanded polyps, natural size; 15A, isolated polyp, enlarged.

Fig. 16.—*Xenia pulsitans*, n.sp., p. 197. Polypary with expanded polyps, slightly enlarged.

Fig. 17.—*Clavularia viridis*, p. 198. Colony of expanded polyps, natural size.

Figs. 18, 19, 20.—*Sarcophyton glaucum*, pp. 18 and 195. Young polyparies of diverse colours, with partially-expanded polyps, natural size; 18A and 18B, isolated polyps, enlarged.

Fig. 21.—*Cornularia pavo*, n.sp., p. 199. Expanded colony-stock, natural size.

Fig. 22.—*Cornularia glauca*, n.sp., p. 199. Expanded colony-stock, natural size; 22A, isolated polyp, enlarged.

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GREAT BARRIER REEF ALCYONARIA.

CHROMO PLATE XI.

GREAT BARRIER REEF CORALS AND ECHINODERMATA.

CHROMO PLATE XI.

GREAT BARRIER REEF CORALS AND ECHINODERMATA.

Fig. 1.—*Isis hippuris*, p. 200. Corallum, with polipiferous cortex adherent to a single terminal branchlet, but denuded from the remaining area, natural size; 1A and 1B, expanded polyps, enlarged.

Fig. 2.—Queensland Black Coral, *Antipathes abies*, pp. 189 and 332. Fragment of branch, natural size; 2A, terminal branchlet; 2B, expanded polyp, enlarged.

Fig. 3.—*Ctenocella pectinata*, p. 200. Branch of corallum, natural size.

Fig. 4.—*Gorgonia australiensis*, p. 200. Terminal branchlet, natural size.

Fig. 5.—*Melitodes ochracea*, p. 200. Terminal branchlet, natural size.

Fig. 6.—*Distichopora coccinea*, p. 202. Corallum, natural size; 6A, portion of corallum, slightly enlarged and turned edgeways to show the polyp orifices.

Figs. 7 and 7A.—Feather Star-fishes, *Antedon* sp., p. 43. Life size and colour.

Fig. 8.—Blue Star-fish, *Linckia lævigata*, p. 43. Life size and colour.

Fig. 9.—Nodose Cushion-star, *Oreaster nodosus*, p. 21. Life size and colour.

Fig. 10.—Gemmiferous Cushion-star, *Culcita grex*, p. 21. Life size and colour.

Fig. 11.—Long-armed Brittle Star, *Ophiomastix annulosa*, p. 121. Life size and colour, with one only of the five arms visible.

Fig. 12.—Needle Urchin, *Diadema setosa*, p. 42. Life size and colour.

Fig. 13.—Slate-pencil Urchin, *Heterocentrotus mammillatus*, p. 103. Life size and colour.

W. Saville-Kent, del. et pinx. ad nat.

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GREAT BARRIER REEF ECHINODERMS.

CHROMO PLATE XII.

GREAT BARRIER REEF HOLOTHURIÆ OR BÊCHE-DE-MER.

CHROMO PLATE XII.

GREAT BARRIER REEF HOLOTHURIÆ OR BECHE-DE-MER.

Figs. 1 and 2.—Commercial Bêche-de-mer, "Red Fish," *Actinopyga obesa*, p. 236. Fig. 1, illustrating ventral and oral regions, with expanded tentacles; and Fig. 2, dorsal view of posterior extremity with vent. Life size and colours.

Fig. 3.—"Green Prickly-Fish," *Stichopus chloronotus*, p. 235. Non-commercial; with extended tentacles, life size and colour; 3A, Polynoe-like annelid, that lives as an external commensal on the body of Stichopus.

Fig. 4.—*Colochirus anceps*, p. 242. Non-commercial; life size and colour.

Fig. 5.—Snake-like Bêche-de-mer, *Holothuria coluber*, p.238. The anterior moiety of the animal, with expanded tentacular crown, is alone visible; natural size.

Fig. 6.—Commercial Bêche-de-mer, "Black Fish," *Actinopyga polymorpha*, n.sp. p. 236. The anterior region only, with expanded tentacles.

Fig. 7.—"Leopard" or "Spotted Fish," *Holothuria argus*, p. 238. The posterior moiety, with vent; natural size.

Fig. 8.—Giant Synapta, *Synapta Beselii*, p. 242. Life size and colour.

Fig. 9.—*Synapta* sp., p. 242. Group of variously-coloured individuals, life size and colour.

Fig. 10.—Fish, "Glass Eel," *Fierasfer* sp., p. 241, that lives as a commensal within the body-cavity of the large teat-fish, *Holothuria mammifera*; natural size.

W. Saville-Kent; del. et pinx. ad nat.

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BARRIER REEF TREPANG OR BÊCHE-DE-MER.

CHROMO PLATE XIII.

GREAT BARRIER REEF MOLLUSCA AND PLANARIANS.

CHROMO PLATE XIII.

GREAT BARRIER REEF MOLLUSCA AND PLANARIANS.

Fig. 1.—Flat-worm or Planarian, *Pseudoceros Kentii*, n.sp., von Graff (*infra*). Life size and colour

Fig. 2.—Flat-worm or Planarian, *Pseudoceros dimidiatus*, n.sp., von Graff (*infra*). Life size and colour.

Fig. 3.—Blue-spotted Octopus, *Octopus pictus* (*infra*). Life size and colour.

Fig. 4.—Sea-hare, *Aplysia* sp. Life size and colour.

Fig. 5.—Flat-worm or Planarian, *Prosthecerœus flavomaculatus*, n.sp., von Graff (*infra*). Life size and colour.

Fig. 6.—Nudibranchiate Mollusc, *Doris* sp. Life size and colour.

Fig. 7.—Nudibranchiate Mollusc, *Doris* sp. Life size and colour.

Fig. 8.—Nudibranchiate Mollusc. ? gen. ? sp. Life size and colour.

Fig. 9.—Nudibranchiate Mollusc, *Ancula* sp. Life size and colour.

Fig. 10.—Group of "Frilled" or "Furbelow" Clams, *Tridacna compressa*, p. 12. Arranged to show only the gaping valves, and the diversified hues of the brilliantly-tinted mantle folds; natural size.

The author is indebted to Professor G. B. Howes for much assistance in the identification of the organisms depicted on the upper portion of this plate. The brilliant coloured Planarians represented by Figs. Nos. 1, 2, 5, proved, on reference, through Professor Howes, to Professor Ludwig von Graff of Graz (the recognised authority on this group), to be in all instances new species, the author's thanks are here tendered for the names bestowed. Nos. 1 and 5 were collected by the author crawling among growing Madreporæ in the Albany Pass and at Thursday Island respectively, and No. 2, under similar conditions, in the vicinity of the Palm Islands.

The remaining most notable species is the blue-spotted Octopus, delineated by Fig. 3. This has been identified for the author, through Professor Howes, with the *Octopus pictus* of Brock, of which Mr. W. E. Hoyle has described a variety, under the title of *O. pictus* var. *fasciatus*, in his monograph on the *Challenger* Cephalopoda. The illustration here given is of interest, since it represents the first occasion on which the natural colours of this species have been recorded. As originally described by Dr. Brock (Zeitschrift für Wissenschaftliche Zoologie, Bd. 36, 1882), the animal (described from a spirit-preserved specimen) was said to be yellowish, with blackish-brown spots. In life, these spots are suffused with glowing shades of the richest ultramarine-blue, each exhibiting for the most part a lighter central area and a darker annular border. The species was collected by the author towards the southern limits of the Barrier district, and on the Victorian coast-line.

BARRIER REEF MOLLUSCS AND PLANARIANS.

CHROMO PLATE XIV.

GREAT BARRIER REEF OYSTERS.

CHROMO PLATE XIV.

GREAT BARRIER REEF OYSTERS.

Figs. 1 and 2.—Coral Rock Oyster, *Ostrea mordax* (Fig. 2 represents var. *cucullata*), p. 246. Lateral and horizontal views; natural size.

Figs. 3 and 4.—Trap-door Oysters, *Ostrea mordax*, var. *cornucopiæformis*, p. 248. Fig. 3, Lateral view; Fig. 4, Dorsal view, with opercular valve removed, showing elongated hinge scar; natural size.

Fig. 5.—Cockscomb Oyster, *Ostrea crista-galli*, p. 244. Lateral view of small specimen; natural size.

Fig. 6.—Saddle Oyster, *Ostrea sellaformis*, n.sp., p. 250. Lateral view; natural size.

Fig. 7.—Black-edged Oyster, *Ostrea nigro-marginata*, pp. 117 and 245. Single valve; natural size.

Figs. 8 and 11.—Commercial "Rock" Oyster, *Ostrea glomerata*, p. 250. 8, Ordinary bunch, natural size, showing at A. hole bored by predatory whelk, *Urosalpinx paviæ;* 9, Vegetarian whelk, *Potamides eberninus*, with attached brood of young rock oysters; 10, Spinous variety of young condition; 11, Ordinary brood and spat.

Fig. 12.—Pea-Crab, *Pinnotheres* sp., p. 214, which lives as a commensal within mantle-folds of mother-of-pearl shell, *Meleagrina margaritifera;* natural size.

Fig. 13.—Crustacean, *Alpheus avarus*, p. 214, which also lives as a commensal within the mantle-folds of the Torres Strait mother-of-pearl shell.

W. Saville-Kent, del. et pinx. ad nat.

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GREAT BARRIER REEF OYSTERS.

CHROMO PLATE XV.

GREAT BARRIER REEF FISHES.

CHROMO PLATE XV.

GREAT BARRIER REEF FISHES.

Fig. 1.—Orange-banded Parrot-fish, *Xiphochilus fasciatus*, Gth., p. 296. Two-thirds natural size.

Fig. 2.—Hodgkinson's Parrot Fish, *Chœrops Hodgkinsonii*, n.sp., p. 296. One-half natural size; 2A, front view of its teeth.

Fig. 3.—Scarlet-banded Parrot Fish, *Cheilinus fasciatus*, Day, p. 295. One-half natural size.

Fig. 4.—Surf Parrot Fish, *Pseudoscarus rivulatus*, C. and V., p. 295. Female, one-half natural size.

Fig. 5.—Surf Parrot Fish, *Pseudoscarus rivulatus*, C. and V., p. 295. Male, one-half natural size; 5A, dental plates of upper jaw.

W. Saville-Kent, del. et pinx. ad nat.

Riddle & Couchman, Imp. London, S.E.

GREAT BARRIER REEF FISHES.

CHROMO PLATE XVI.

GREAT BARRIER REEF FISHES.

CHROMO PLATE XVI.

GREAT BARRIER REEF FISHES.

Fig. 1.—Fringe-finned Trevally, *Caranx radiatus,* MacLeay, p. 289. One-fourth natural size

Fig. 2.—Diamond Trevally, *Caranx gallus,* Lin., p. 289. One-sixth natural size.

Fig. 3.—Needle Fish, *Amphisile scutata,* p. 307. One-eighth natural size.

Fig. 4.—Blue-banded Coral Fish, *Labroides bicincta,* n.sp., p. 308. Natural size.

Fig. 5.—Striped Sole, *Solea heterorhina,* Blk., p. 298. One-half natural size.

Fig. 6.—Trigger Fish, *Centriscus scolopax,* Cuv., p. 307. Natural size.

Fig. 7.—Banded Amphiprion, *Amphiprion Clarkii* (juv.), Benn., p. 308. Natural size.

Fig. 8.—Crimson Coral Fish, *Polyacanthus Queenslandiæ,* n.sp., p. 309. Natural size.

Fig. 9.—Gold-Finned Coral Fish, *Labroides auropinna,* n.sp., p. 308. Natural size.

Fig. 10.—Horned Trunk Fish, *Ostracion cornutum,* Lin., p. 309. One-half natural size.

Fig. 11.—Yellow-tailed Glyphidodon, *Glyphidodon luteo-caudata,* n.sp., p. 308. Natural size.

Fig. 12.—Crimson-spotted Goby, *Gobius Douglasi,* n.sp., p. 310. Natural size.

Fig. 13.—Crimson-scribbled Coral Fish, *Julis lunaris,* p. 296. Natural size.

Fig. 14.—Blue-breasted Coral Fish, *Julis cyano-ventor,* n.sp., p. 296. Natural size.

Fig. 15.—Alligator Pipe Fish, *Gastrotokeus biaculeata,* Bl., p. 310. Natural size.

W. Saville-Kent, del. et pinx. ad nat.

Riddle & Couchman, Imp. London, S.E.

GREAT BARRIER REEF FISHES.

APPENDIX A.

CLASSIFIED LIST OF QUEENSLAND FOOD FISHES.

FAMILY—PERCIDÆ (PERCHES).

Genera and Species.—Ctenolates ambiguus; Dentex filifer; Diagramma amabile, D. amicium, D. crassilabre, D. multivittatum, D. reticulatum; Diploprion bifasciatum; Dules Haswelli, D. humilis, D. produles; Enoplosus armatus; Genyoroge amabilis, G. bengalensis, G. nigricauda, G. notata var. sexlineata, G. regia, G. rubicauda, G. Sæbæ, G. unicolor; Gerres abbreviatus, G. argyreus, G. filamentosus, G. longicaudus, G. ovatus, G. ovena, G. profundus, G. punctatus, G. splendens; Glaucosoma scapulare; Homalogrystes luctuosus; Lates calcarifer; Lobotes auctorum; Mesoprion aurivittatus, M. carponotatus, M. chrysokenia, M. helenæ, M. Johnii, M. obscurus, M. roseigaster, M. superbis, M. waigiensis; Murrayia bramoides, M. cyprinoides, M. Güntheri; Oligorus goliath; O. Macquariensis, O. terræ-reginæ; Pentapus paradiseus; Pristipoma hasta, P. maculatum, P. nigrorubrum, P. variegatum; Priacanthus junonis; Psammoperca waigiensis; Riverina fluviatilis; Serranus armatus, S. australis, S. carinatus, S. crapao, S. diacanthus, S. estuarius, S. fuscoguttatas, S. geometricus, S. Gilberti, S. hexagonatus, S. lanceolatus, S. mars, S. mysticalis, S. Outalibi, S. rubriniger, S. stigmipoma, S. subfasciatus, S. subniger, S. suilexus, S. thyrsites, S. tsirimenara; Synagris tœniopterus; Therapon acutirostris, T. ater, T. carbo, T. caudovittatus, T. cavifrons, T. Cuvieri, T. Elphinstonensis, T. fasciatus, T. fuliginosus, T. Hillii, T. longulus, T. maculosus, T. nigripinnis, T. parviceps, T. percoides, T. Richardsoni, T. servus, T. spinosior, T. terræ-reginæ, T. theraps, T. trivittatus, T. truttaceus, T. unicola.

FAMILY—SQUAMIPINNES (SCALE-FINNED FISHES).

Genera and Species.—Drepane punctata; Scatophagus ætate-varians, S. argus, S. brunneus, S. chameleon, S. multifasciatus, S. quadratus, S. semi-strigatus; Scorpis æquipinnis, S. vinosa; Toxotes jaculator.

FAMILY—MULLIDÆ (RED MULLETS).

Genera and Species.—Mulloides armatus; Upeneoides roseus, U. rubriniger, U. tragula, U. vittatus; Upeneus malabaricus.

FAMILY—SPARIDÆ (SEA-BREAMS).

Genera and Species.—Chrysophrys australis, C. hasta, C. sarba; Girella carbonaria, G mentalis, G simplex; Lethrinus chrysostomus, L. flavescens, L. imperialis, L. lachrymans, L. laticaudus, L. mansenoides, L. margaritifer, L. nebulosus, L. nematacanthus, L. ornatus, L. regius, L. Richardsoni, L. rostratus, L. viridis; Pagrus major, P. spinifer, P. unicola.

FAMILY—SCORPÆNIDÆ (ROCK-CODS OR ROCK-GURNETS).

Genera and Species.—Centropogon australis, C. echinatus, C. marmoratus, C. nitens, C. robustus; Scorpæna bellicosa, S. binæensis, S. cardinalis, S. cruenta, S. panda; Synancidium horridum.

FAMILY—TEUTHIDIDÆ (SPINED TREVALLIES).

Genus and Species.—Teuthis albopunctata, T. flava, T. gibbosus, T. java, T. mixtus, T. nebulosus, T. teuthopsis, T. vermiculata, T. vitticauda.

FAMILY—POLYNEMIDÆ (TASSEL FISHES).

Genus and Species.—Polynemus cœcus, P. indicus, P. macrochir, P. multiradiatus, P. Sheridani, P. specularis, P. tetradactylus.

FAMILY—SCIÆNIDÆ (JEW FISHES).

Genera and Species.—Corvina albida, C. australis, C. axillaris, C. canina, C. comes, C. miles; Umbrina Mulleri.

FAMILY—TRICHIURIDÆ (BARRACOUTAS).

Genus and Species.—Trichiurus haumela, T. savala.

FAMILY—CARANGIDÆ (TREVALLIES AND SCADS).

Genera and Species.—Caranx armatus, C. aurifer, C. bucculentus, C. cives, C. compressus, C. ecclipsifer, C. edentulus, C. filigera, C. gallus, C. Gervaisii, C. hippos, C. ignobilis, C. nobilis, C. procaranx, C. radiatus, C. speciosa, C. Valenciennesii; Chorinemus lysan, C. maculosus, C. tooloo; Equula argentea, E. asina, E. decora, E. dispar, E. edentula, E. fasciata, E. geneoides, E. lineolata, E. nuchalis, E. ovalis, E. profunda, E. simplex, E. spiniceps; Platax orbicularis, P. teira; Psettus argenteus; Seriola grandis, S. Lalandi; Stromateus niger; Temnodon saltator, T. tubulus.

FAMILY—SCOMBRIDÆ (MACKERELS).

Genera and Species.—Cybium Commersoni; Elacate niger; Scomber antarcticus; Thynnus McCoyi.

FAMILY—TRACHINIDÆ (WHITINGS).

Genus and Species.—Sillago ciliata S. gracilis, S. maculata.

FAMILY—COTTIDÆ (FLATHEADS AND GURNARDS).

Genera and Species.—Lepidotrigla Vergeri; Platycephalus fuscus, P. insidiator, P. japonicus, P. Staigeri; Trigla polyommata.

FAMILY—GOBIIDÆ (LOTERS).

Genus and Species.—Eleotris aporosa, E. crescens.

FAMILY—SPHYRÆNIDÆ (SEA-PIKES).

Genus and Species.—Sphyræna Commersoni, S. dentatus, S. langsar, S. obtusata.

FAMILY ATHERINIDÆ (SAND-SMELTS).

Genus and Species.—Atherina elongata, A. lacunosa, A. pinguis, A. stercus-muscarum.

FAMILY—MUGILIDÆ (GREY MULLETS).

Genera and Species.—Mugil argenteus, M. cephalotus, M. convexus, M. delicatulus, M. dobula, M. longimanus, M. marginatus, M. nasutus, M. Peronii, M. splendens, M. tade, M. waigiensis; Myxus elongatus.

FAMILY—FISTULARIIDÆ (PIPE-FISHES).

Genus and Species.—Fistularia serratus.

FAMILY—LABRIDÆ (WRASSES OR PARROT-FISHES).

Genera and Species.—Cheilinus fasciatus; Chœrops Hodgkinsoni; Cossyphus aurifer, C. latro; Odax nebulosus; Pseudoscarus rivulatus.

FAMILY—OPHIDIIDÆ (LINGS).

Genus and Species.—Congrogadus subducens.

FAMILY—PLEURONECTIDÆ (FLAT-FISHES).

Genera and Species.—Ammotretis ovalis; Arnoglossus Bleekeri; Neorhombus ocellatus; Pardachirus pavoninus; Plagusia brevirostris, P. guttata, P. notata; Psettodes erumei; Pseudorhombus multimaculatus; Solea heterorhina; Synaptura armata, S. cinerea, S. Fitzroyensis, S. inermis, S. nigra, S. Selheimi.

FAMILY—SILURIDÆ (CAT-FISHES).

Genera and Species.—Arius thalassinus; Copidoglanis curtus, C. labrosus, C. lævis, C. tandanus; Neosilurius Hyrtli; Plotosus anguillaris, P. elongatus, P. laticeps.

FAMILY—SCOPELIDÆ (BUMMALOE-FISH).

Genus and Species.—Saurida argentea.

FAMILY—SCOMBRESOCIDÆ (GAR-FISHES).

Genus and Species.—Arrhamphus sclerolepis; Belone annulata, B. depressa, B. gavialoides, B. Kreffti, B. melanotus, B. Staigeri, B. tyrannus, B. vorax; Exocætus volans, E. nigripinnis; Hemirhamphus argenteus, H. Commersoni, H. intermedius, H. marginatus, H. regularis.

FAMILY—OSTEOGLOSSIDÆ (BARRAMUNDAS).

Genus and Species.—Osteoglossum Jardinei, O. Leichardti.

FAMILY CLUPEIDÆ (HERRINGS).

Genera and Species.—Brisbania Staigeri; Chanos salmoneus; Chatoëssus elongatus, C. erebi, C. nasus; Clupea hypselosoma, C. Novæ-Hollandiæ, C. profundis, C. Ranelayi, C. Richmondi, C. sundaica, C. tembang, C. torresiensis; Elops saurus; Engraulis carpentariæ, E. nasutus; Megalops cyprinoides; Sprattelloides delicatulus.

FAMILY—CHIROCENTRIDÆ (SILVER-BAR FISHES).

Genus and Species.—Chirocentrus dorab.

FAMILY—MURÆNIDÆ (EELS).

Genera and Species.—Anguilla australis, A. macassensis, A. marginipinnis, A. mauritiana, A. Petelli, A. pseudothyrsoidea, A. Rheinhardtii, A. Richardsoni; Conger labiatus, C. marginatus; Gymnomuræna concolor; Muræna afra, M. fimbriata, M. macassarensis, M. melanospila, M. nebulosa, M. Petelli, M. picta, M. pseudothyrsoidea, M. tesselata, M. undulata; Muræncsox cinereus; Ophichthys cephalozona, O. elapsoides, O. episcopus.

FAMILY—SIRENIDÆ (LUNG-FISHES).

Genus and Species.—Ceratodus Forsteri.

FAMILY—RHINOBATIDÆ (SKATES).

Genus and Species.—Rhinobatus granulatus.

APPENDIX B.

Preliminary List of Corals, Sea Anemones, and allied Organisms collected by the Author in the districts of the Great Barrier Reef and Torres Strait.

Order I.—ACTINARIA, *Simple Anemones.*

With this list of the Actinaria, and the following one of the Zoantharia, the Author has been enabled to incorporate the species collected in Torres Strait by Professor A. C. Haddon. These types, when differing from those obtained by the Author, are marked with an asterisk. The diagnoses of Professor Haddon's species are published in the *Proceedings of the Royal Dublin Society*, Part I., 1893, p. 116.

Actineria dendrophora, *Haddon.**
Actinodendron alcyonoideum.
,, arboreum.*
Actinioides Dixoniana, *Haddon.**
,, Sesere, *Haddon.**
Adamsia miriam, *Haddon.**
Alicia rhadina, *Haddon.**
Anemonia citrina, *Haddon.**
,, Kwoiam, *Haddon.**
Cerianthus nobilis, *Haddon.**
Condylactis aspera, *Haddon.**
,, Gelam, *Haddon.**
,, Ramsayi, *Haddon.**
Corynactis hoplites, *Haddon.**
Cryptodendrum adhæsivum.*
Discosoma Haddoni, n.sp.
,, Kenti, *Haddon.*
,, macrodactylum, *Haddon.**
Discosoma Malu, *Haddon.**
,, nummiforme.
,, rubra-oris, n.sp.
Heterodactyla Hemprichi.
,, hypnoides, n.sp.
Megalactis Griffithsi, n.sp.
Minyas torpedo ? *
Paraphellia Hunti, *Haddon.**
,, lineata, *Haddon.**
Phellia Devisi, *Haddon.**
,, (?) sipunculoides, *Haddon.**
Phymanthus muscosus.*
,, simplex, *Haddon.**
Physobrachia Douglasi, nov. gen. n.sp.
Rhodactis bryoides, *Haddon.**
,, Howesii, n.sp.
Thoe (?) Milmani, *Haddon.**
Viatrix cincta, *Haddon.**

ORDER II.—ZOANTHARIA, *Compound Anemones.*

Acrozoanthus Australiæ, nov. gen. n.sp.
Gemmaria Macmurrichi, *Haddon.**
,, Mutuki, *Haddon.**
Isaurus asymmetricus, *Haddon.**
Parazoanthus cœsia.
Parazoanthus Howesii, *Haddon.**
,, Kochii, *Haddon.**
Zoanthus Coppingeri.
,, Jukesii, *Haddon.**
,, Macgillivrayi, *Haddon.**

ORDER III.—MADREPORARIA, *Stony Corals.*

Acanthastræa sp.
Alveopora clavaria.
,, retusa.
,, viridis.
Astræa radians.
Astreopora punctifera.
Caulastræa distorta.
Cœloria Esperi.
,, sinensis.
,, sp.
,, sp.
Cryptabacia talpina.
Cycloseris cyclolites.
Cyphastræa sp.
,, sp.
Dendrophyllia coccinnia.
,, axifuga.
,, sp.
Echinopora aspera.
,, horrida.
,, rosularia.
Euphyllia fimbriata.
,, glabescens.
,, rugosa.
Favia amicorum.
,, Bowerbanki (?)
,, Ehrenbergi (?)
Fungia crassitentaculata.
,, discus.
,, lacera.
,, sp.
,, sp.
,, sp.
Galaxea Esperi.
,, musicalis (?)
,, sp.
Goniastræa eximia.
,, Grayi.
,, sp.
,, sp.
Goniopora sp. (? lobata).
Halomitra pileus.
Heliastræa sp.
,, sp.
Herpetolitha limax.
Heteropsammia Michelini.
Hydnophora Demidoffi.
,, microcona.
,, rigida.
Isophyllia australis.
Lithophyllia lacrymalis (?)
Lophoseris crassa.
,, cristata.
,, sp.
Mæandrina sp.
Merulina ampliata.
Micrabacia crustacea.
Montipora expansa.
,, foliosa.
,, scabricula.
,, verrucosa.
,, sp.
,, sp.
,, sp.
,, sp.
Mosleya latistellata.

Mussa corymbosa.
,, multilobata.
,, sp.
Oculina arbuscula.
,, fasciculata, n.sp.
Pectinia Jardinei, n.sp.
Phymastræa sp.
Plesiastræa Peroni.
,, versipora.
Pocillopora acuta.
,, brevicornis.
,, damicornis.
Porites astræoides.
,, divaricata.
,, furcata.
,, sp.
,, sp.
Prionastræa robusta.
,, sp.
,, sp.
Psammocora sp.
,, sp.
Rhipidogyra sp. (? laxa)
Rhizangia sp. ?
Rhodarœa calicularis.
,, fruticosa, n.sp.
Seriatopora caliendrum.
,, elegans (?)
,, hystrix.
,, octoptera.
Solenastræa sp.
,, sp.
Stylopora palmata.
,, pistillata.
Symphyllia hemispherica.
,, sinuosa.
Trachyphyllia amarantum.
Tridacophyllia laciniata.
,, lactuca.
,, Queenslandiæ.
Turbinaria cinerascens.
,, crater.
,, patula.
,, peltata.
,, sp.

Species of the genus Madrepora from the Author's Barrier Reef collection, identified and named by Mr. George Brook, F.L.S.

M. (Isopora) cuneata, *Dana.*
— (,,) palifera, *Lamk.*
— (,,) plicata, *Brk.*
— abrotanoides, *Lamk.*
— ambigua, *Brk.*
— arbuscula, *Dana.*
— aspera, *Dana.*
— australis, *Brk.*
— bæodactyla, *Brk.*
— brevicollis, Brk.
— brevicollis, v. pustulosa, *Brk.*
— Bruggemanni, *Brk.*
— bullata, *Brk.*
— canaliculata, *Klz.*
— capillaris, *Klz.*
— cerealis, *Dana.*
— conferta, *Quelch.*
M. convexa, *Dana.*
— coronata, *Brk.*
— cribripora, *Dana.*
— decipiens, *Brk.*
— ,, var., *Brk.*
— delicatula, *Brk.*
— digitifera, *Dana.*
— divaricata, *Dana.*
— echidnæa, *Lamk.* (New Guinea.)
— effusa, *Dana.*
— Elseyi, *Brk.*
— eurystoma, *Klz.*
— exilis, *Brk.*
— formosa, *Dana.*
— fruticosa, *Brk.*
— gemmifera, *Brk.*
— grandis, *Brk.*

M. hebes, *Dana.*
— „ v. comparta, *Brk*
– Hemprichi, v. obtusata, *Brk*
— humilis, *Dana.*
— hyacinthus, *Dana.*
— Kenti, *Brk.*
— latistilla, *Brk.*
— laxa, *Lamk.*
— longicyathus, *Ed. & H.* (New Guinea.)
— loripes, *Brk.*
— millepora, *Ehrb.*
— monticulosa, *Brugg.*
— muricata, f. cervicornis, *Lamk.*
— „ f. palmata, *Lamk.*
— micropthalma, *Verr.*
— ornata, *Brk.*
— patula, *Brk.*
— pectinata, *Brk.*
— pocillifera, *Lamk.*
M. prostrata, *Dana.*
— pulchra, v. stricta, *Brk.*
pyramidalis, *Klz.*
— recumbens, *Brk.*
— rosaria, *Dana.*
— rosaria, v. dumosa, *Brk.*
— rosaria, v. pygmæa, *Brk.*
— sarmentosa, *Brk.*
— secunda, *Dana.*
— selago, *Stud.*
— seriata, *Ehrb.*
— squamosa, *Brk.*
— surculosa, *Dana.*
— syringodes, *Brk.*
— tubigera (?) *Horn.*
— Valenciennesii, *Ed. & H.*
— valida, *Dana.*
— variabilis, *Klz.*
— violacea, *Brk.*

Order IV.—ANTIPATHARIA, *Black Corals.*

Antipathes abies.
Cirrhipathes anguina.*
„ sp. (? spiralis)

Order V.—ALCYONARIA, *Flexible Corals.*

Alcyonium flexibile.
„ latum.
„ murale.
Clavularia viridis.
Cornularia auricula, n.sp.
„ glauca, n.sp.
„ pavo, n.sp.
„ tubiporoides, n.sp.
Ctenocella pectinata.
Gorgonia australiensis.
„ flexile.
Heliopora cœrulea.
Isis hippuris.
Melitoides ochracea.
Plexaura salicornoides.
Sarcophyton glaucum.
„ radiata.
Spongodes, sp.
Tubipora musica.
Xenia brunnea, n.sp.
„ elongata.
„ ochracea, n.sp.
„ pulsitans, n.sp.

Class—HYDROZOA.

Order—Hydrocorallia.

Distichopora coccinea
Millepora alcicornis.
Millepora ramosa.
„ sp.
„ sp.

INDEX.

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Date Due

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1 Chart

CHART OF THE GREAT BARRIER REEF AREA.